X-BAR TANDEM
VOL. 1 - DESCRIPTION

CROSSBAR TANDEM SWITCHING SYSTEM

VOLUME I

CROSSBAR TANDEM SWITCHING SYSTEM

VOLUME 1

General and Detailed Description

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INTRODUCTION

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CROSSBAR TANDEM SWITCHING SYSTEM INTRODUCTION

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CROSSBAR TANDEM SWITCHING SYSTEM

INTRODUCTION

The crossbar tandem system is designed to provide for intra-area tandem trunking in panel and crossbar areas and to serve also as an interconnecting means between the offices in these areas and the surrounding step-by-step and manual offices. The crossbar tandem is suitable for use in a full 3-digit area, a combination 2 and 3-digit area, or a straight 2-digit area.

Provision is made for handling on a tandem trunking basis both customer dialed traffic and operator dialed or keyed traffic. No provision has been made as yet for operator positions at tandem for handling traffic from manual operators on a straightforward trunking basis. However, the general design permits of adding tandem operator equipment should the demand for such an arrangement materialize. Figure 7-1 at the end of this section illustrates the principle elements of the system and the types of traffic handled.

The traffic presented to the tandem office for completion may be divided into four distinct classes, the PCI traffic, the revertive pulse traffic, the dial pulse traffic and multi-frequency pulse traffic, depending upon the method employed in transmitting the signaling information to the tandem office.

The PCI method is employed for customer dialed traffic from panel and No. 1 crossbar offices when centralized automatic message accounting is provided in the tandem office. It utilizes PCI pulses from senders in the panel and No. 1 crossbar offices to control tandem switching and to furnish accounting information.

The revertive pulse method is employed for subscriber dialed traffic from panel and crossbar offices and for operator dialed or keyed traffic from these offices using the originating sender. It utilizes the office brush and office group revertive pulses from the senders in the panel or crossbar office to control the tandem switching.

The dial pulse method may be used for traffic from panel or crossbar DSA boards of the dialing type direct to tandem without using originating senders. It is required for traffic from all other dialing switchboards or from step-by-step senders. The dial pulse trunks to tandem may be of the loop signaling, composite or simplex type and may have voice repeaters if desired. Accordingly, trunks may be brought into the tandem office from toll centers some distance away and thus provide alternate completing facilities to a metropolitan area if the regular facilities at the toll board in that area are out of service or overloaded. It is this ability to receive calls over any trunk that will pass dial pulses that makes the dial pulse tandem particularly valuable for emergency routings.

The multi-frequency pulse method may be used for operator keyed traffic; the originating source must be, of course, equipped with multi-frequency oscillators.

The customer dialed traffic may originate in panel offices, crossbar offices, or step-by-step offices of the "fringe" type equipped with senders. The operator traffic may originate at any type of dialing or key pulsing DSA board or toll board or at manual switchboards equipped with dials.

The apparatus employed, the general equipment design, and the fundamental circuit operation of the crossbar tandem equipment are similar to the corresponding features of local crossbar offices.

The major equipment units of a crossbar tandem office are: trunk frame, trunk link frame, office link frame, sender link frame, sender, marker connector, marker, B position, position link frame, transverter, recorder, billing indexer, and master timer. The office may have a maximum of 20 trunk link frames with a physical maximum of 3200 tandem trunks (incoming) and 4000 tandem completing trunks (outgoing). The crossbar tandem uses the sender-marker method of operation with 2-wire, one-way trunks, incoming and outgoing.

A call coming in on a tandem trunk is connected to the proper type of sender, the PCI type, the revertive pulse type, the dial pulse type or the multi-frequency type. After the code information is registered in the sender, a marker is called in, the information is decoded, and the tandem trunk link and office link switches are closed through to connect the tandem trunk to an outgoing trunk to the desired destination. The extension of the call beyond the tandem point is controlled by the tandem sender except that on a PCI call via revertive pulse tandem senders, the pulses are sent from the originating sender through the tandem sender to the terminating PCI equipment.

PRINCIPLE EQUIPMENT ELEMENTS

Trunk Link Frame

The trunk link frame is a two bay structure which mounts ten 6-wire, 200 point crossbar switches (primaries) on the left-hand bay and ten 3-wire, 200 point switches (secondaries) on the right-hand bay. Above the crossbar switches are the multi-contact relays and other equipment making up the trunk link connector. Space is provided for trunk link connector facilities for a maximum of eight markers.

A trunk link frame may serve a maximum of 160 trunks although somewhat fewer (say 140 or 150) may load the frame under specific conditions. The arrangement of two trunks per select magnet on the eight upper cross points of the primary switches is similar to the 160 trunk incoming line frame in the local crossbar system. The secondary bay has outlets to 200 office junctors.

Sender Link Frame

The sender link frame is a two-bay structure. The right-hand bay mounts the eight 200 point, four wire crossbar switches for the primary-secondary link arrangement and the sender subgroup connector multi-contact relays. On the left-hand bay the relays for the "A" and "B" controller circuits are mounted in a casing and above this casing are the trunk group connector multi-contact relays.

A sender link frame is required for each 100 tandem trunks. The sender link and controller circuits mounted on this frame serve to associate 100 tandem trunks with a maximum of 40 to 80 tandem senders depending on whether the secondaries are split. The trunks appear on the horizontals of the lower four switches and the senders on the horizontals of the upper four switches.

Office Link Frame

The office link frame is a two-bay structure mounting the ten 3-wire, 200 point primary switches in the left bay and the ten 4-wire, 200 point secondary switches on the right. The multi-contact relays and other apparatus making up the office link connector are located above the crossbar switches. The equipment and circuits are identical with the office link frame in the local crossbar system. The 200 office junctors which terminate on the primary verticals interconnect the trunk link frames with the office link frame.

The ten regular secondary switches normally provide for 100 outgoing trunks per frame. This number may be raised by splitting some or all of the secondary switch levels or by adding office extension frames or both. If any office link frames are equipped with extension frames all office link frames must be so equipped.

Although the secondary switches, both regular and extension are 4-wire switches, either 3-wire or 4-wire cabling can be furnished to the M.D.F. Any trunk circuits to step-by-step offices (either loop, CX or SX) receiving traffic from through supervision tandem trunks require the 4th wire. The test lines from the office multiple also require the 4th wire and in this case this wire can be cabled directly if not already provided.

Sender Frames

The tandem sender frame has mounting space for five revertive pulse senders or four dial pulse senders.

Revertive Pulse Sender

Calls from panel and crossbar offices involving senders in those offices will utilize the revertive pulse type of sender at tandem. This type of sender generates revertive pulses to "count down" the subscriber senders or key pulsing senders in the originating offices.

The tandem routing is obtained from the office brush and office group revertive pulses. If the tandem sender records office brush selections from 0 to 4 associated with a GB indication from the sender link, the marker recognizes it as a 1st 50 code indication. If 5 to 9 office brush is recorded a 2nd 50 code indication results. With a GA indication from the sender link a 0-4 office brush gives a 2nd 50 code result, and a 5-9 office brush gives a 1st 50 code result. For completion to panel or crossbar offices the tandem sender records and repeats the numerical digit revertive pulses. Two different codes can be combined for crossbar multi-office termination using "add 5" on incoming group selections for one of the codes.

For completion to call indicator destinations requiring either local PCI or tandem PCI pulses, the revertive pulse tandem sender records only the office brush and office group revertive pulses and then closes a path through for the PCI pulses to be sent from the originating sender. The final heavy positive pulse is recognized by the tandem sender as a signal to set the tandem trunk in the talking condition and release.

For completion to a manual "B" operator or to a 3-digit operator on a straight-forward basis the connection is set up without making TG test. This method of completion is used only on calls from operators.

For completion to step-by-step offices or step-by-step tandem the revertive pulse tandem sender records the numerical digit revertive pulses and translates them to step-by-step pulses. For five or six digit step-by-step completion it will precede the four numerical digits by the required one or two extra digits under the guidance of the marker route relay.

The step-by-step pulsing on either a four and five digit basis or a four, five and six digit basis feature is optional in the revertive pulse sender. The step-by-step pulsing feature includes three types of pulsing circuit conditions under control of the route relay.

(a) Battery and ground pulsing

(b) Loop pulsing interoffice

(c) Loop pulsing to outgoing repeaters

Dial Pulse Sender

The operating features of the dial pulse tandem sender are generally similar to a local crossbar subscriber sender of the "timed release" type with a step-by-step outgoing class added. This sender is designed to receive dial pulses from dialing operators, step-by-step fringe office senders, and step-by-step key pulsing positions. It is arranged to complete calls by any one of a number of methods as follows:

(a) By revertive pulses either with or without panel office brush and group selections.

(b) By step-by-step pulses either 4, 5 or 6 digits. The three types of pulsing circuit conditions as in the revertive sender are provided.

(c) By PCI pulses either tandem or local.

(d) Without pulsing to straight-forward or 3-digit operators.

The straight-forward termination (d) is used only on calls from operators. Since no TG test is made on these calls there would be a possibility of a false change on subscriber dialed calls if a reversed trunk were encountered.

The office codes dialed into the sender may be 2-digit, 3-digit or combination 2 and 3-digit according to the numbering plan in the area. In the combination 2 and 3-digit areas the customary code restriction that all codes beginning with a particular "A" digit must be either two digits or three digits obtains.

The sender is equipped with the "11" toll directing feature to permit direct dialing between two different numbering areas with conflicting codes. If an "11" indication is received this will be transmitted to the marker which will cause a second group of codes to be indicated. As a straight 2-digit sender it will handle 80 codes and as a 3-digit sender 800 codes, both without using the "11" toll directing feature.

Multi-Frequency Sender

The operating features of the multi-frequency tandem sender are similar to the dial pulse tandem sender except that the multi-frequency tandem sender receives incoming information by means of multi-frequency pulses which are registered as digits in the sender. In addition the multi-frequency tandem sender has provisions to multi-frequency out pulse.

PCI Sender

This sender is designed for use in a crossbar tandem office to assist in completing calls dialed by subscribers in panel and crossbar areas. It is primarily intended to complete to offices outside of the local exchange area, and so panel call indicator (P.C.I. or C.I.) type of pulsing is used into tandem in order to get sufficient office code usage, and also in order that party letter may be pulsed out from panel and No. 1 crossbar offices. Extension of customer dialing is provided by placing the charging equipment at tandem so that it may be used jointly by a number of local offices. Automatic message accounting equipment will be used to record the details of calls. Since calls are to be completed outside of the local exchange area, completion may be by:

(1) Revertive

(2) Dial multi-frequency or

(3) Call-indicator pulsing either directly to a terminating office or for D.P. and M.F. through another tandem point.

Marker Connector Frames

A fully equipped marker connector has facilities for reaching eight markers but on jobs with fewer markers the connectors may, of course, be partially equipped.

Marker Connector for Revertive Pulse Senders

A marker connector frame mounts three marker connectors for use with revertive pulse senders. Each connector serves the five senders on one revertive pulse sender frame. These five senders normally make up a sender subgroup.

Marker Connector for Both Dial Pulse Senders and Revertive Pulse Senders

A marker connector frame mounts three marker connectors for use with dial pulse, revertive pulse, multi-frequency, or PCI senders. One connector normally serves the five senders of a sender subgroup.

Marker Frame

The tandem marker basic unit is mounted on a two-bay framework. As equipped on this size frame, it will serve revertive pulse senders only and may have up to 120 route relays. A supplementary frame located to the right of and adjacent to the basic frame will mount some of the equipment for dial pulse, multi-frequency, and PCI sender operation and an additional 120 route relays with their cross-connection terminal strips.

The tandem marker is similar in its function to the originating marker in the local crossbar system. Briefly, it receives the code information from the tandem sender, decodes on a route relay basis, passes back certain decoded information to the sender, and sets up the call through the crosspoints on the trunk link frame and the office link frame. It is capable of receiving 100 routes from the revertive senders and as many as 800 from the dial pulse senders.

TANDEM TRUNK CIRCUITS

Several types of tandem trunk circuits are available to serve the variety of requirements involved in the areas where crossbar tandem is applicable. There are three distinct types of supervision control, the "through supervision," the "repeated supervision" and "CX supervision." Figure 8-2 shows the fundamental supervision features of each and illustrates the differences between them.

It will be noted that with the through supervision trunk the circuit which holds the connection during talking includes the trunk conductors in and out and the equipment at the originating, intermediate and terminating points. Consequently the supervision range may be limited by the originating or terminating office equipment.

With the repeated supervision trunk, on the other hand, the holding circuit for the tandem trunk is independent of the holding circuit for the completing trunk. Consequently this type of trunk has a greater range and a greater freedom from false disconnects as well as other advantages.

METHOD OF OPERATION ON VARIOUS TYPES OF CALLS

Customer Dialing from Panel or Crossbar Office

Call to Panel or Crossbar Office

Following the completion of dialing of the office code the originating subscriber sender, controls district selections in the usual manner, an idle trunk from the district multiple is selected to the crossbar tandem office and the originating sender makes office test followed by office brush and office group selections. The closure of the bridge for office brush selections causes the tandem trunk circuit to connect the incoming tip and ring of the trunk through a tandem sender link circuit to a revertive pulse tandem sender.

The tandem sender transmits revertive pulses to the originating sender and records the number of pulses required to satisfy the originating sender for office brush selections (0 to 9), and then for office group selections (0 to 9).

This records in the tandem sender one of 100 possible routes. The tandem sender then transfers this record to the tandem marker which converts it into a route relay operation. The tandem marker then causes the selection of an idle trunk to the terminating office corresponding to this route. The tandem sender proceeds to generate the required revertive pulses for the successive numerical selections, incoming brush, incoming group, final brush, final tens and final units. Thus the record of the wanted number is transferred from the originating sender to the tandem sender. As the exchange of information between the originating and tandem senders for each of these selections is completed (such as incoming brush for example) control of the corresponding terminating office selections is initiated on the outgoing side of the tandem sender. In other words, the selections are repeated in the tandem sender on a stage-by-stage basis.

The tandem sender is held on the connection until the originating office advances the subscriber district selector to the talking position when it is removed from the connection. When this is recognized at tandem the control of the terminating trunk is transferred to the originating office with the tandem trunk held by a series supervisory relay receiving current from the terminating office through this relay to the bridge at the originating office. When the originating bridge is broken on hang-up of the calling subscriber, the tandem equipment is restored to normal.

The tandem sender has the ability to "add 5" on incoming group selections if required to reach the multi-office terminating crossbar unit over a common group of completing trunks. This is controlled by the tandem route relay. Otherwise, the crossbar completion is the same as for panel.

Call to Manual Office

For a call to a manual office on a PCI basis, the operation is identical up to and including the office selections but on a PCI call the tandem marker then causes the tandem sender to cut the pulsing path from the originating office through to the terminating office with a polarized relay in series in the tandem sender to recognize the heavy positive pulse at the completion of PCI pulses, after which it establishes the supervision control path straight through the trunk and the tandem sender is removed from the connection.

Call to Step-by-Step Office

For a call to a step-by-step office, the tandem sender operation is similar to that described for panel completion except that in this case the outgoing pulses are on a decimal step-by-step basis and at a nominal speed of 10 pulses per second. The panel revertive selections for incoming brush and group and for final brush, tens and units are translated back to the four digits corresponding to the listed number and used for controlling the step-by-step switches.

Should the tandem marker determine from the route relay that one or two extra digits are required (5 or 6-digit pulsing), the tandem sender transmits the proper digit or digits ahead of the numerical portion and these extra digits, if required, are determined by the cross-connections on the route relay in question.

Customer Dialing from Step-by-Step Offices

This type of operation assumes a sender in the originating step-by-step office which stores the required office code and numerical registration, and transmits them to a dial pulse sender at the tandem office via an outgoing pulse repeater at the step-by-step office.

When the originating customer has completed dialing the office code and the trunk to tandem has been selected, a bridge is placed on the originating end of the trunk which causes the tandem trunk circuit to be connected through a sender link to a dial pulse tandem sender. When the tandem sender is connected, it causes a momentary battery reversal to the originating office which serves as a start dialing signal to the originating step-by-step sender. When this operation is completed, dial tone is sent over the talking circuit to the originating office and the tandem sender is ready to receive dial pulses. (The dial tone will not be heard by the calling subscriber but is included as a maintenance aid and design convenience.)

The completion of this momentary reversal causes the originating sender to start transmitting dial pulses. It will then transmit the office code to tandem. As rapidly as the customer completes subsequent digits these will be transmitted to the tandem sender. The pulsing speed of the originating sender on these calls is 20 pulses per second.

When the office code digits are received the tandem sender transmits these to one of the tandem markers, which controls the selection of the proper outgoing trunk and furnishes the tandem sender with the information required to complete the call.

Beyond this point, the operations are similar to the operation of a crossbar local office subscriber sender, that is, the tandem sender controls the revertive pulse selections to panel or crossbar offices, or generates PCI pulses to manual offices. In addition, the tandem sender is capable of generating dial pulses (on a 10-pulse-per-second-basis) for completion to a step-by-step office, and these are sent as received.

The tandem sender is held on the connection until it is through with its function. It then establishes the control in the tandem trunk circuit and is removed from the connection.

Operator Key-Pulsing (D-C) from Panel or Crossbar DSA Switchboard

From key-pulsing DSA boards calls may be completed through tandem in either of two ways; through operator district selectors or through jack ended trunks direct to tandem. The operator district routing will, in general, be used for assistance traffic to terminating offices within the dialing area of some or all of the subscribers served by the "A" board. The direct trunks to tandem will be used for calls (A-B toll particularly) which the subscriber can not dial but for which code points and route relays can be provided in the local office decoder or marker. The two methods of operation are described separately below.

Call to Panel, Crossbar, Step-by-Step or Manual PCI Office Using Operator District Routing

The operator district multiple is ordinarily cross-multipled to the subscriber district multiple. The trunk group to crossbar tandem appearing on the subscriber district frames, accordingly, appears also on the operator district frames. When the operator plugs into an operator district jack and keys an office code and number the local decoder or marker will route the call over the tandem trunk group if this is the normal routing for subscriber dialed calls. The circuit operation is similar to that described in Paragraph 4.01 for customer dialing from panel or crossbar offices.

Call to Panel, Crossbar, Step-by-Step or Manual PCI Office Over Direct Trunk to Tandem (Skip-District)

When the operator plugs into a trunk in the outgoing trunk multiple to the tandem office the outgoing trunk circuit attaches a key-pulsing sender in the originating office and indicates to this sender that this is to be a "skip-district" call. The operator proceeds to key the office code and the wanted number. Following the keying of the office code and start key the key pulsing sender makes office test followed by office brush and office group selections in accordance with the local decoder or marker route relay information. The closure of the bridge for office brush selections causes the tandem trunk circuit and its associated revertive pulse tandem sender to operate in the same manner as for a customer dialed call as described in Paragraph 4.01.

Two additional classes of calls for operator key pulsing traffic which are not available for customer dialed calls may be provided if modifications are made in the key-pulsing senders. These classes are as follows:

Call to a Manual Office on a Straight-forward Basis

For calls to manual offices operated on a straight-forward basis, the DSA operator, after selecting the trunk to crossbar tandem, keys an office code followed by a start key and then waits for order tone from the terminating "B" operators position. When this is received, the DSA operator passes the numerical part of the order to the "B" operator who completes the call in accordance with the usual practice. The circuit operation is as follows: On receipt of the office code digits followed by the start key signal the DSA key-pulsing sender proceeds with office selections to the tandem sender and trunk test. The originating sender makes trunk closure and then transfers the control to the bridge of the DSA cord. The tandem sender passes the office brush and group registration to the tandem marker which selects an idle trunk to the desired office but no bridge is placed on the outgoing trunk until the trunk closure bridge is applied from the originating office. This bridge operates the trunk supervisory relay in the completing trunk resulting in order tone to the DSA operator. Should the order tone begin before the originating sender has cleared it will be heard by the operator via a by-path in the key-pulsing sender established for this type of call. For this type of operation, the tandem sender does not check the straight-forward completing trunk for continuity or polarity.

Operator Dialing from Panel or Crossbar DSA Switchboard

From dialing DSA boards calls may be completed through tandem in either of two ways; through dialing district selectors or through jack-ended trunks direct to tandem. The methods of operation are as follows:

Operator Dialed Call Using Dialing District Selector

When an operator makes a call through a dialing district she uses a subscriber sender and its associated decoder or translator equipment and the call is routed through tandem if this is the normal routing for customer dialed calls. The method of operation is the same as for customer dialed calls described in Paragraph 4.01, and the switching at tandem is controlled by a revertive pulse tandem sender.

Operator Dialed Call Using Direct Trunk to Tandem

When a dialing DSA board is provided with jack-ended trunks direct to the tandem office the operators have access to all tandem terminations. For this type of call, the DSA operator selects a trunk in the outgoing trunk multiple which is connected at tandem to dial pulse tandem senders and when a tandem sender is connected the operator will receive dial tone. No senders are involved in the originating office. When the trunk to tandem is selected the trunk supervision is in the receiver off-hook condition, and the calling cord lamp is dark and remains so until the tandem sender is connected. When a tandem sender is found the supervision will become receiver on-hook, the calling cord lamp will light and dial tone will be heard. The operator proceeds from this point with dialing the office code and subscriber number as for a local call handled via an operator dialing district. For completion to classes other than straight-forward or 3-digit operator the call proceeds as for a customer dialed call from a step-by-step office. For completion to a straight-forward manual trunk to "B" switchboards or to 3-digit operator trunks the operation is similar to that described for key-pulsing "skip-district" calls to these trunks.

Operator Dialed Calls from Step-by-Step DSA Switchboards

Step-by-step DSA boards are provided with jack-ended trunks direct to tandem. The operation is the same as described in Paragraph 4.19 above.

Operator Dialed Calls from Manual Local or Toll Switchboards

For calls from toll switchboards not modified for the "start dialing" signals, the operation is the same as that described above in Paragraph 4.21 except that dial tone is omitted on these calls and the operator depends on the cord lamp. When the trunk to tandem is selected, the supervision is in the receiver off-hook condition and the toll cord calling lamp will be dark. When the tandem sender is found and is ready to receive dial pulses, the supervision is reversed and the lamp is lighted and remains lighted until the called party answers. This start dialing signal arrangement is obtained by cross-connections on the sender link frame associated with the decade of tandem trunks and by trunk wiring options.

For calls from toll switchboards which have been modified for the start dialing signals the operation is as above, except that the signals are received on the start dialing lamp instead of the cord lamps.

For calls from manual local offices, the trunks may be connected to operate on a start dialing signal as above, or they may be connected to receive in addition a dial tone signal as for the DSA switchboard, Paragraph 4.21.

NOTES:

1. FOR P.C.I. PULSING EITHER LOCAL (5 DIGIT) OR TANDEM (7 OR 8 DIGIT) THE REVERTIVE PULSE TANDEM SENDERS EXTEND THE ORIGINATING OFFICE PULSES THROUGH TANDEM. THE DIAL PULSE SENDERS GENERATE THE P.C.I. PULSES.
2. THESE (4 DIGIT, 5 DIGIT AND 6 DIGIT PULSING) MAY BE COMBINED IN A SINGLE TRUNK GROUP.

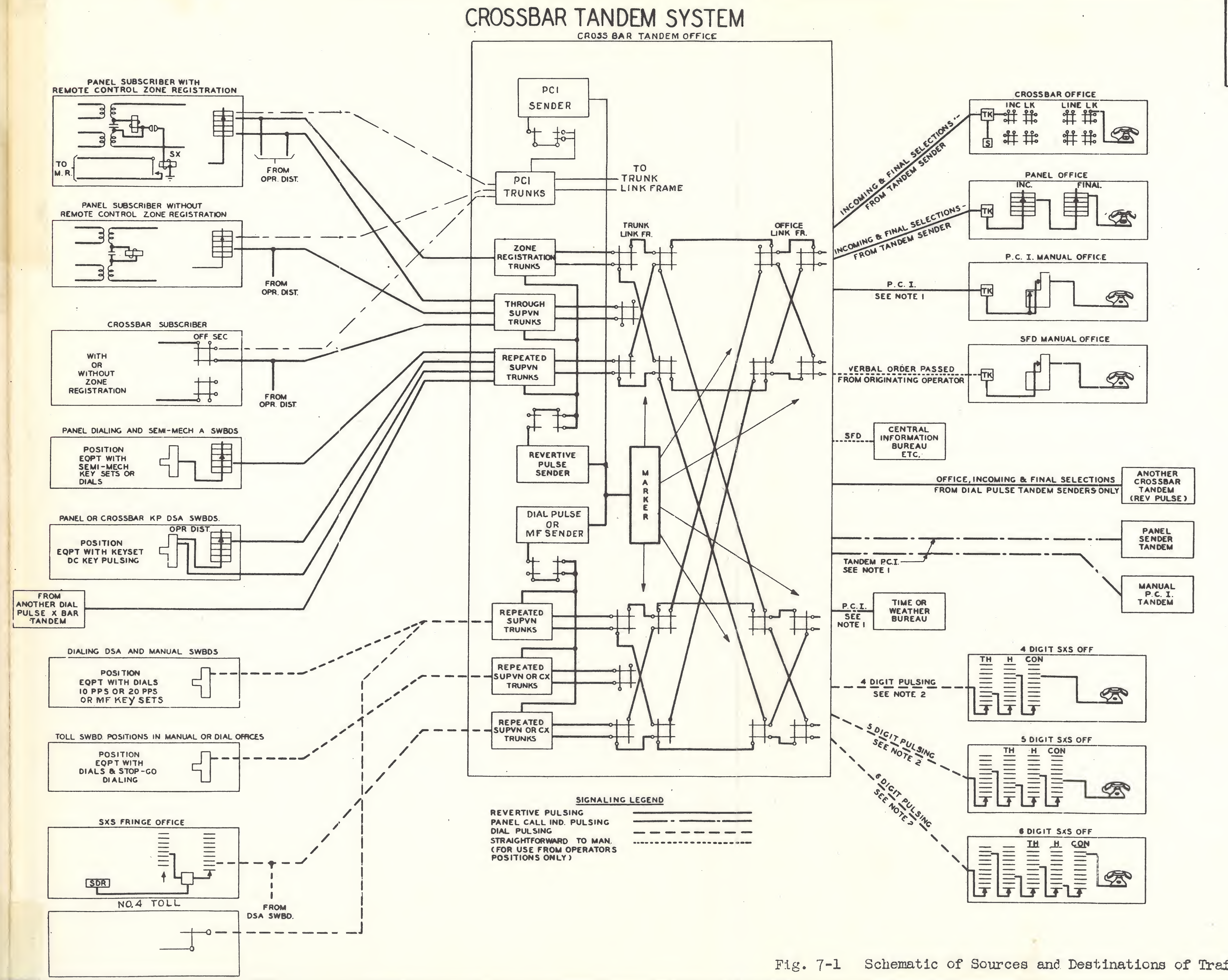
CROSSBAR TANDEM SYSTEM
CROSS BAR TANDEM OFFICE
PANEL SUBSCRIBER WITH REMOTE CONTROL ZONE REGISTRATION
TO M.R.
SX
FROM OPR. DIST.
PANEL SUBSCRIBER WITHOUT REMOTE CONTROL ZONE REGISTRATION
FROM OPR. DIST.
CROSSBAR SUBSCRIBER
OFF SEC
WITH OR WITHOUT ZONE REGISTRATION
FROM OPR. DIST.
PANEL DIALING AND SEMI-MECH A SWBDS
POSITION EQPT WITH SEMI-MECH KEY SETS OR DIALS
PANEL OR CROSSBAR KP DSA SWBDS.
OPR DIST
POSITION EQPT WITH KEYSET DC KEY PULSING
FROM ANOTHER DIAL PULSE X BAR TANDEM
DIALING DSA AND MANUAL SWBDS
POSITION EQPT WITH DIALS 10 PPS OR 20 PPS OR MF KEY SETS
TOLL SWBD POSITIONS IN MANUAL OR DIAL OFFICES
POSITION EQPT WITH DIALS & STOP-GO DIALING
SXS FRINGE OFFICE
SDR
NO.4 TOLL
FROM DSA SWBD.
PCI SENDER
PCI TRUNKS
TO TRUNK LINK FRAME
ZONE REGISTRATION TRUNKS
THROUGH SUPVN TRUNKS
REPEATED SUPVN TRUNKS
REVERTIVE PULSE SENDER
DIAL PULSE OR MF SENDER
REPEATED SUPVN TRUNKS
REPEATED SUPVN OR CX TRUNKS
REPEATED SUPVN OR CX TRUNKS
TRUNK LINK FR.
OFFICE LINK FR.
MARKER
SIGNALING LEGEND
REVERTIVE PULSING
PANEL CALL IND. PULSING
DIAL PULSING
STRAIGHTFORWARD TO MAN. (FOR USE FROM OPERATORS POSITIONS ONLY)
INCOMING & FINAL SELECTIONS FROM TANDEM SENDER
CROSSBAR OFFICE
INC LK
LINE LK
TK
S
INCOMING & FINAL SELECTIONS FROM TANDEM SENDER
PANEL OFFICE
INC.
FINAL
TK
P.C.I. SEE NOTE I
P.C.I. MANUAL OFFICE
TK
VERBAL ORDER PASSED FROM ORIGINATING OPERATOR
SFD MANUAL OFFICE
TK
SFD
CENTRAL INFORMATION BUREAU ETC.
OFFICE, INCOMING & FINAL SELECTIONS FROM DIAL PULSE TANDEM SENDERS ONLY
ANOTHER CROSSBAR TANDEM (REV PULSE)
PANEL SENDER TANDEM
TANDEM P.C.I. SEE NOTE I
MANUAL P.C.I. TANDEM
P.C.I. SEE NOTE I
TIME OR WEATHER BUREAU
4 DIGIT PULSING SEE NOTE 2
4 DIGIT SXS OFF
TH H CON
5 DIGIT PULSING SEE NOTE 2
5 DIGIT SXS OFF
TH H CON
6 DIGIT PULSING SEE NOTE 2
6 DIGIT SXS OFF
TH H CON

Fig. 7-1 Schematic of Sources and Destinations of Traffic

GENERAL

GENERAL

GENERAL

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TANDEM INCOMING TRUNK CIRCUIT

This circuit is used to connect an incoming trunk to common tandem equipment and to assist in completing a call to a terminating office.

Generally speaking there are three types of supervision control employed.

1. Through supervision which continues the talking and signalling path throuh the tandem office and therefore limits the range of supervision.
2. Repeated supervision which bridges the talking and signalling path and controls the terminating equipment when a call has been established, thus increasing the range of supervision.
3. CX supervision which employs composite signalling inward from the originating equipment and repeated supervision outward to the terminating equipment.

This circuit is arranged:

1. To recognize seizure by an originating office and to request a sender upon seizure.
2. To continue the pulsing and control leads to the sender and to recognize the completion of sender functions.
3. To recognize trunk closure and close the tip and ring toward the terminating end upon completion of the sender functions.
4. In the case of repeated supervision trunk circuits to recognize on hook and off hook conditions at the terminating end and relay these conditions to the originating end.
5. In the case of remote control zone registration trunk circuits to time the call and to transmit the required number of charge pulses to the originating end.
6. To recognize disconnection at the originating end and restore to normal.

SENDER LINK AND CONTROLLER CIRCUIT

1. This circuit provides a means of connecting the tandem trunk circuits to the tandem sender circuits.

2. This circuit provides a means of connecting 100 trunks to a maximum of 40 senders.

3. Eight switches are provided; four to connect the trunks to the sender link controller and four to connect to an idle sender.

4. This connection is established by means of two controller circuits (A & B).

5. The trunks are divided into 10 sub-groups of ten trunks each and the senders are divided into sub-groups with a maximum of five senders.

6. The controllers have access to all trunks and to twenty senders. However, each controller on a numerical basis prefers either the odd or even numbered sub-groups of trunks.

7. Sequence circuits are provided to prevent simultaneous connections to two trunk groups, trunks, sender groups or senders.

8. The sender group and sender selected are determined on a preference basis by the trunk group and trunk desiring service.

9. Timing features are provided to determine that all functions are completed within the allotted time.

TRUNK LINK AND CONNECTOR CIRCUIT

This circuit provides means for a tandem marker to establish a connection between an incoming trunk on the primary switches and any office junctor on the secondary switches.

The primary switches are six point switches, accommodating two trunks, on each of levels 2 to 9; an even numbered trunk on the three left hand springs and an odd numbered trunk on the three right hand springs. Horizontals (levels) 0 to 1 are used as directing levels. These levels are split between each vertical and linked to the horizontals of the ten secondary switches, two to each secondary switch.

The capacity of a trunk link frame is 160 incoming trunks, 16 trunks on each of the primary switches 0 to 9.

The secondary switches accommodate 200 office junctors which are cabled to the office junctor grouping frame. There they are connected to the leads from the office link primary switches.

The markers connect to the trunk link frame through the trunk link connector circuit.

The channel number in a crossbar tandem office to be used in tracing channel trouble tickets is the vertical number of the trunk link primary switch, the trunk link frame secondary switch number, the office link frame primary switch number and the vertical number of the office link secondary switch.

TANDEM REVERTIVE PULSE SENDER CIRCUIT

This circuit is used to complete calls from panel or crossbar offices to other panel, crossbar or manual offices.

This circuit is arranged:

1. To recognize seizure by a sender link and controller and to record the number of the trunk link frame upon which the originating trunk appears.

2. To maintain the connection when once established between the trunk, sender link and sender.

3. To furnish revertive pulses to the originating sender so as to satisfy that sender for office brush and group selection and to count these revertive pulses in the tandem sender and record them as the office brush and group code.

4. To summon a marker connector so that the sender may be connected to a marker; then, transmit to and receive from the marker the necessary information for completing the call.

5. To arrange for a second or third trial connection to the marker in case of a trouble condition.

6. To receive from the trunk an indication that the connection has been established between the incoming and outgoing trunks.

7. After the necessary information has been received from the originating sender, on a full selector call to complete terminating trunk test and to control the equipment in the terminating offices, used in establishing the connection.

On PCI or operator class calls, to connect the incoming and outgoing trunks together, through supervisory equipment in the tandem sender so that a connection may be setup in the terminating office.

To provide the necessary timing features to ascertain that all operations are completed within the allotted time.

Under control of the timing circuit to provide an "automatic priming" feature so that both the originating and terminating equipment can be rebased in the event of a failure.

To cancel the automatic priming feature on full selector calls by the operation of a key. This feature may be used by the central office forces to facilitate maintenance.

To provide a traffic control feature at the discretion of the traffic forces, to change the timing interval, arranged to time for assignment on PCI calls from 60 to 80 seconds to 20 to 40 seconds. This is accomplished by means of a plug and jack at the SMB panel.

Testing facilities are provided for maintenance purposes through an automatic sender test frame.

Equipment removing senders from service are provided at the sender make-busy frame.

TANDEM DIAL PULSE SENDER CIRCUIT

This circuit is used to complete calls from manual, DSA and toll switchboard positions equipped for dialing and step-by-step customers.

It is used to complete calls to panel, crossbar, step-by-step, other tandem offices and to operator and desk positions.

This circuit is arranged:

1. To recognize seizure by a sender link and controller and to record the number of the trunk link frame upon which the originating trunk appears.
2. To record the class of service of the originating trunk.
3. To receive dial pulses and to record them as numerical digits.
4. To summon a marker by means of a marker connector and transmit to and receive from the marker the necessary information for completing the call.
5. To arrange for a second or third trial connection to the marker in case of a trouble condition.
6. To control out selections to the distant office either on a revertive, step-by-step, PCI, or straight forward basis.
7. To provide the necessary timing features to ascertain that all operations are completed within the allotted time.

TANDEM MULTI-FREQUENCY SENDER CIRCUIT

This circuit is used to complete calls from manual, DSA, toll switchboard positions equipped for MF key pulsing or senders arranged to transmit multi-frequency pulses.

It is used to complete calls to panel, crossbar, RP, MF or DP terminating crossbar, RP, MF or DP tandem, manual, step-by-step, and to operator and desk positions.

This circuit is arranged:

1. To recognize seizure by a sender link and controller and to record the number of the trunk link frame upon which the originating trunk appears.
2. To record the class of service of the originating trunk.
3. To receive MF pulses in combinations of two frequencies per digit and to record them as numerical digits.
4. To summon a marker by means of a marker connector and transmit to and receive from the marker the necessary information for completing the call.
5. To arrange for a second or third trial connection to the marker in case of a trouble condition.
6. To control out selections to the distant office either revertive, step-by-step, multi-frequency, PCI or straight forward.
7. To provide the necessary timing features to ascertain that all functions are completed within the allotted time.

TANDEM PCI SENDER CIRCUIT

This circuit is used to complete calls from panel and crossbar offices. It is primarily intended to complete to offices outside of the local exchange area and so panel call indicator (PCI) type of pulsing into tandem is used in order to get sufficient office code usage and also in order that party letters may be pulsed out from panel and #1 crossbar offices.

Common charging equipment located in the crossbar tandem office and the automatic message accounting equipment will record the details of the calls.

This circuit is used to complete calls to panel, crossbar, step-by-step, other tandem offices and to operator and desk positions.

This circuit is arranged:

1. To recognize seizure by a sender link and controller and to record the number of the trunk link frame upon which the originating trunk appears.
2. To record the class of service of the incoming trunk, the rate class if more than one rate class is required, and an indication as to the AMA treatment of the call if the sender is used for both AMA and non-AMA calls.
3. To receive PCI pulses and record them as digits.
4. Upon reception of all pulses on an AMA call to establish a talking path between the subscriber and the AMA operator.
5. To accept the calling subscribers number as keyed by the AMA operator.
6. To seize a transverter after the calling number has been registered and transmit to it the information required for charging the call.
7. To receive a position release signal from the transverter and to proceed with the completion of the call.
8. To summon a marker by means of a marker connector and transmit to and receive from the marker the necessary information for completing the call.

9. To arrange for a second or third trial connection to the marker in case of a trouble condition.
10. To recall the marker on a same trial basis in the event that the transverter encounters trouble.
11. To provide the necessary timing features to ascertain that all functions are completed within the allotted time.

MARKER CONNECTOR CIRCUIT

This circuit is used to connect a tandem sender to a tandem marker.

Each marker connector will handle a maximum of 5 senders and 8 markers.

Preference and sequence circuits are provided to prevent simultaneous connections and cause connection to senders and markers on a preferred basis.

Features are provided for making marker connectors busy to a particular marker.

A timing circuit is provided to ascertain that the marker connector connects to and releases from the sender and marker in the allotted length of time.

A "traffic regulator" circuit is provided to prevent one marker connector which is handling a call from handling a second call until all other marker connectors waiting for a marker have been served.

The "traffic regulator" feature may be cancelled in case of a time-out under control of a key. A minor alarm is given whenever this key is operated.

MARKER CIRCUIT

This circuit is designed to decode the office brush and group code as received in the tandem sender; to select and test the outgoing trunk group and the channels between the incoming and outgoing trunk; to transmit to the sender the necessary information for completing the call, class of call and compensating resistance; and to establish a connection between the incoming and selected outgoing trunks by operating the proper select and hold magnets.

The principle functions of the marker are:

1. To receive the office brush and group code and the trunk link frame number from the sender through the marker connector.
2. To operate a different route relay for each code received. The route relay when operated, to give the following information: class of call, compensating resistance and trunk guard to the sender; pair of office frame number, trunk level, trunk group start, trunk group end, zone, peg count and overflow message register information to the marker.
3. After the operation of the route relay, the marker connects to the pair of office frames, upon which the desired trunk group appears.
4. When a test has been made, to determine that a previous call is not in the marker stage, the marker selects the trunk level, of the desired trunk group on the pair of office frames just connected.
5. When the trunk level has been determined the marker indicates the start and end points of the desired trunk group within the selected trunk level. After the trunk group has been selected in this manner, the marker tests all of the trunks within the group and selects the first idle trunk.
6. The marker receives from the selected trunk an indication of the location of the trunk within the marker test group, whether the trunk is on the odd or even frame, the number of the office link secondary switch upon which the selected trunk appears and whether the trunk is on the right or left side of the switch.
7. To connect through the trunk link and connector circuit to the trunk link frame upon which the incoming trunk appears.

8. To transmit a release signal to the sender so that the sender will release from the marker when an idle outgoing trunk has been selected and a connection has been established to the proper trunk link frame.

9. To select an idle combination of trunk links, office junctors and office links; to connect the incoming trunk to the outgoing trunk.

10. To operate the office link and trunk link primary and secondary select magnets, then to operate the office link and trunk link hold magnets in order to close the crosspoints and establish the connection between the incoming and outgoing trunks.

11. To provide three short interval timing periods; to time for the operation of the route relay after seizure; connection to the trunk link frame after seizure; and for the release of the marker after connection to the trunk link frame.

12. To provide a long interval timing period; to time for the release of the marker after seizure. This timing is furnished so that the marker may be released from a trouble condition, in the event of a failure of the short time-out circuit.

The marker performs its functions in two stages; the decoder stage, which is the reception and transmission of information to the sender; and the marker stage, which is the testing and selection of an idle outgoing trunk and the connection through an idle channel from the incoming to the outgoing trunk.

There are three sets of leads out through from the sender to the marker by the marker connector; they are the receiving, transmitting and control leads. They are arranged to rotate calls over succession groups of junctors.

The marker is arranged to reverse the order of testing for an idle trunk and for an idle channel, in case a second trial call is indicated from the sender.

When testing for an idle outgoing trunk, the marker is arranged to test the out trunk multiple in groups of forty trunks.

When testing for an idle channel, the marker is arranged to test the channels in groups of twenty.

Testing facilities for the marker are provided in the trouble indicator circuit.

OFFICE LINK AND CONNECTOR CIRCUIT

This frame provides a means for a tandem marker to establish through the office links a connection between any office junctor on the primary switches and any outgoing trunk on the secondary switches. This is done to connect in part the leads from an incoming trunk to the leads of an outgoing trunk.

This frame is composed of 10 primary and 10 secondary, 200 point switches. Provision is made for an office link extension frame for each office frame adding ten more secondary switches.

The ten primary switches provide 200 office junctors to the trunk link secondary switches.

The ten secondary switches provide 100 outgoing trunks if the switches are not split or 200 outgoing trunks if the switches are split. A total number of trunks between 100 and 200 may be provided, in multiples of twenty, by splitting pairs of levels on each secondary switch.

The primary switches are cabled to the office junctor grouping frame. The secondary switches (outgoing trunks) are cabled to the main frame.

The markers connect to the office link frame through the office link connector circuit.

TRUNKS

TANDEM TRUNK FRAME AND TRUNKS

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TANDEM TRUNK FRAME AND TRUNKS

TANDEM TRUNK FRAME

Purpose

The tandem trunk frame is required for mounting the required equipment associated with incoming trunks.

Description

The tandem trunk frame is a single bay structure having capacity for mounting the equipment associated with sixty, thirty or twenty incoming trunks depending on the type.

The trunks on each frame are numbered 00 to 19, 00 to 29, or 00 to 59. Each 10-trunk group, 00 to 09, 10 to 19, etc., is so connected at the tandem sender link frame as to constitute a primary switch subgroup. All trunks within a group of 10 must be of the same type with regard to the type of sender required, revertive, dial pulse or multi-frequency pulsing. All trunks within a group of 10 must be served by the same trunk link frame and must be given the same treatment with regard to "below 5" or "above 5" office brush selection. These requirements arise from the fact that the frame and group indication involved are given to the tandem sender by primary switch subgroups on the tandem sender link frame.

Each 10-trunk group, 00 to 09, 10 to 19, etc., associated with a trunk frame is so connected at the tandem trunk link frame as to contribute one trunk to each of the 10 primary switches on the frame Fig. 1. This will be the corresponding trunk level on each primary switch at the trunk link frame. Each primary switch accommodates a maximum of 16 trunks, two on each levels 2 to 9.

The adjacent even and odd trunk groups of 10 trunks on a trunk frame terminate in pairs at the trunk link frame. Trunks 00 to 09, 20 to 29 or 40 to 49 will normally appear as the even trunks on a level and trunks 10 to 19, 30 to 39 or 50 to 59 as the odd trunks. The trunk numbering consequently indicates by the units digit, 0 to 9, the trunk link primary switch on which it appears and, by the tens digit, even or odd, the position on the level.

Appearing on each trunk frame is a designation card on which additional information is entered for identifying the associated trunk link frame and switch level assignment for each group of 10 trunks. It requires 2-2/3 trunk frames to accommodate one trunk link frame. The trunk frames may or may not be assigned to the trunk link frames in sequence. This will depend upon the type of traffic. The calling rate and holding time may be such that a trunk link frame cannot be loaded to its full 160-trunk capacity.

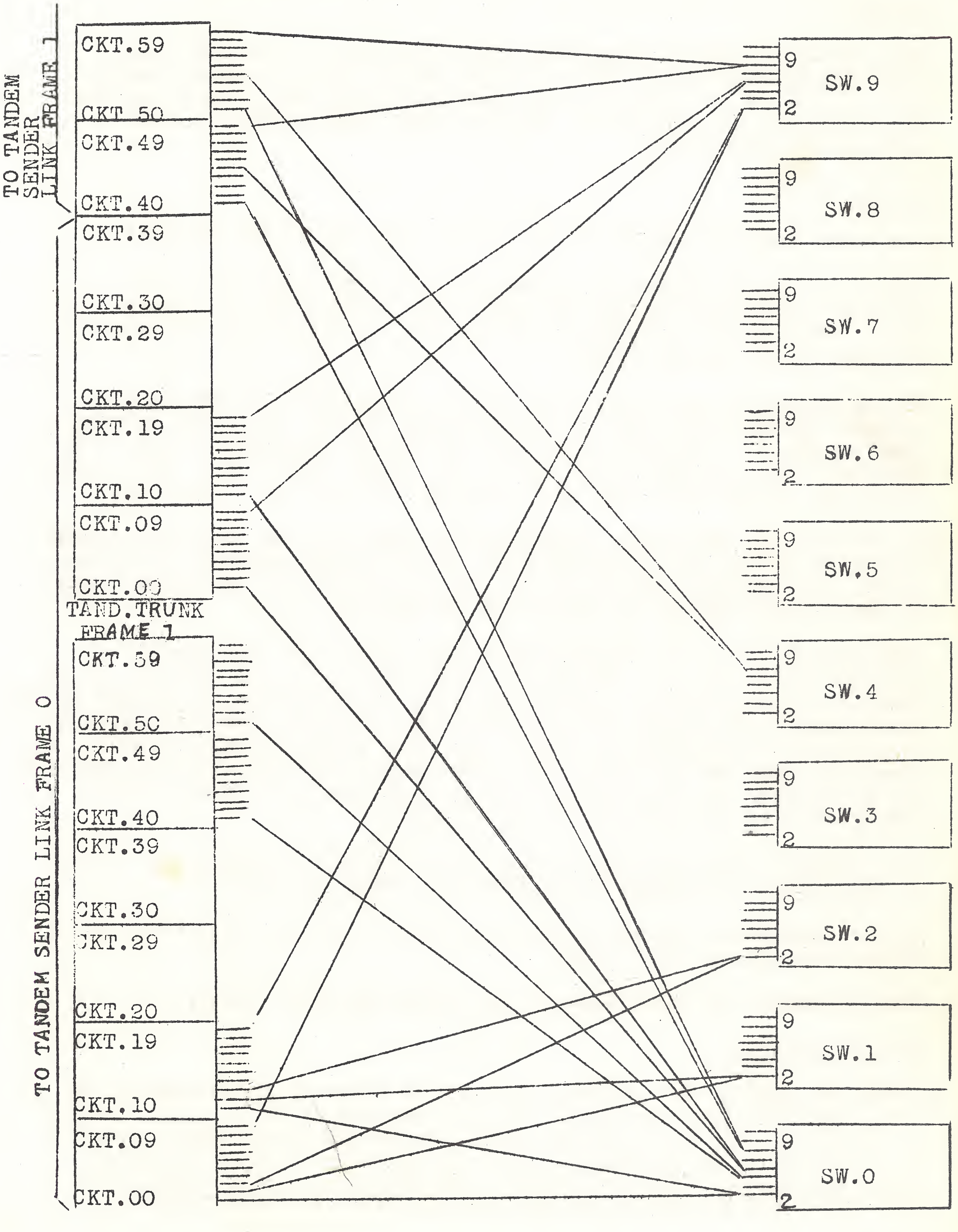
Where the trunk link frames are to accommodate 110, 130, or 150 trunks, it may become necessary to assign trunks of a group of 20 to 2-trunk link frames instead of only 1-trunk frame.

The two groups of 10 trunks should appear on corresponding levels on both frames, assuming the position on the level to be indicated by the tens digit of the group involved in each case. On each trunk link frame, these groups will occupy the highest equipped level. This permits the remaining trunks to be assigned in the usual manner and to retain uniform significance from the numbering standpoint.

CROSSBAR TANDEM OFFICE
ASSOCIATION OF TANDEM TRUNK CIRCUITS & TRUNK LINK FRAME

60 TRUNK FRAME
160 TRUNK LINK FRAME

TANDEM
TRUNK LINK FRAME 0
(PRIMARY BAY)



TRUNK CIRCUIT---INCOMING FROM LOCAL OR TOLL OFFICE REPEATED SUPERVISION

Purpose

This circuit is used for completing calls incoming on a loop dial basis from step-by-step manual, toll or tandem offices, or on a revertive basis from crossbar or on an M.F. pulsing basis from manual toll, D.S.A., manual, No. 4 toll or tandem offices to crossbar, panel, step-by-step, manual offices or tandem offices.

Seizure OS-00

A The tandem trunk is selected by an operator or by mechanical equipment.

When a dialing "A" switchboard operator selects this trunk the A relay operates immediately, because the plug of her cord circuit is inserted into a trunk jack in the position multiple which is associated with the tip and ring of the incoming trunk.

When a dialing "A" switchboard operator or a key pulsing "A" switchboard operator selects this trunk on a multi-frequency basis, the A relay operates when the plug is inserted in the trunk jack at the originating office. The operated A relay grounds the ST lead to the tandem sender link. This causes the sender of the proper type to be selected and connected to the trunk.

T At the time that the T relay operates, the sender link has selected a tandem sender and closed the link crosspoints from the tandem sender to the tandem trunk. The operating ground for the T relay is applied at the tandem sender to the CO lead, through the sender link crosspoints.

Operation of the T relay removes ground from the ring of the trunk in preparation for dialing. Battery is removed from the tip by operation of the T relay. An overlap exists between the trunk and the sender, as battery through the L relay of the sender has been connected to the tip, thereby maintaining a closure to the originating office. Operation of the T relay on multi-frequency calls removes battery and ground from the tip and ring in preparation for MF pulsing. At this time there is an overlapping battery and ground connected to the tip and ring by the MF sender.

The T relay in operating releases the trunk A relay which opens the ST lead to the sender link allowing it to advance for disconnection.

If the transmission repeater termination feature is being used, it is opened by the operation of the T relay.

Removes ground from the PB lead to the traffic register circuit.

Operating Switches

F After the code has been dialed in the case of a dialing "A" switchboard or after the multi-frequency pulses have been received on a M.F. call, a marker is connected. The marker grounds the DC lead to the tandem sender operating a DC relay which in operating, extends the operating ground to the tandem trunk causing the F relay to operate. The operation of the F relay, is an indication that the marker has selected the trunk link frame required for the call and is cutting through the individual trunk which originated the call, to the trunk link frame for control purposes. Upon the operation of the F relay, its operating ground is again extended over the LC lead to the trunk link frame operating an LC relay. After connecting the ground over the LC lead toward the trunk link frame into the marker, the marker returns ground in the opposite direction, back over the LC lead to lock the F relay and at the same time extending it back to the sender link DC lead to the tandem sender locking the DC relay. The closure of the S lead to the SL lead is used during the check of the channel. Grounding the M and M1 leads operates the required primary select magnets on the trunk link frame.

After the marker has selected a channel between the trunk to the terminating office and this tandem trunk, it closes the crosspoints of the switches involved. If satisfied with the conditions of the switches in the channel selected, it releases the F relay by opening the LC lead. Upon the release of the F relay, it closes ground from the operated contacts of the T relay to the S lead of the trunk link frame, to lock in the hold magnets associated with the selected channel. The marker checks for this locking ground and then releases.

The T, R, FT and FR leads are connected directly to the sender with no bridged apparatus in the trunk.

Trunk Closure

D When the tandem sender has completed its terminating office selections on a full selector call, it receives reversed battery and ground from the terminating office. This causes the tandem sender to advance for trunk closure.

If the call is a P. .I. call and a dial pulse tandem sender is used, the sender functions and advances for trunk closure after sending the heavy positive pulse.

If the call is a multi-frequency, thus using an M.F. tandem sender, the sender functions and advances for trunk closure after it has received reversed battery and ground from the terminating office on full mechanical calls or the heavy positive pulse on a P.C.I. termination.

In any of the above calls, the tandem sender will ground the D lead and operate the tandem trunk D relay.

D1 The D1 relay operates from the D relay operated.

It removes the shunts from the A relay when operated (T option).

Prevents the reclosure of the transmission repeater termination when the T relay releases later ("Y" option).

Closes the CS relay across the tip and ring toward the called office to indicate when the called subscriber has answered.

DC LEAD

The DC lead is grounded by the operation of the D1 relay. This causes the tandem sender to open the CO lead releasing the T relay.

D2 The D2 relay operates on the release of the T relay. The D2 relay closes the A relay operating path back to the tip and ring leads to the originating office.

When the A relay operate path is closed back to the tip and ring leads it depends upon Z or X wiring with W wiring as to whether battery is going to be returned on the tip or ring lead to the originating office. If Z wiring is used, it is returned on the tip. If X wiring is used, it is returned on the ring. On multi-frequency calls the M.F. tandem sender has battery at this time connected to the ring, therefore, when the relay operates the A relay battery must be connected to the ring. This is necessary for the purpose of maintaining the same supervision at the originating office during the transfer from the M.F. sender back to the incoming trunk.

On calls being served by dial pulse or multi-frequency senders, the A relay in operating for trunk closure just locks the D relay for supervision on the originating office. Grounding of the DC lead on these types of calls, serves to give the disconnect signal.

The D relay is slow release to hold over any momentary open of the tip and ring leads from the originating office.

Supervision

CS When the called subscriber answers, the CS relay operates on reverse battery and ground from the incoming circuit at the terminating office. The operation of the CS relay causes the operation of the T relay repeating the reversal to the originating office for supervision. The T relay locks and connects an additional ground to the S lead. Battery reversals from the incoming trunk in the called office causes the CS relay to operate and release. The operation and releasing of the CS relay, with the D2 relay operated, causes the operation and release of the T relay. The T relay in operating and releasing causes a similar reversal of the battery and ground on the A relay toward the calling office thereby repeating the supervision. The battery reversals from the called office may be due to a busy back or overflow signal or the flashing of the switchhook.

Disconnection

If the calling office disconnects, the A relay releases causing the release of the D, D1, CS, T and D2 relays. The D relay in figure A is slow release so that it will not release on dial pulses or momentary openings due to key operation at a distant switchboard. Relay D in figure B is slow enough in releasing to cover any irregularity in the contact closure of relay A.

The release of the D2 relay opens the S lead ground, releasing the channel hold magnets. The time consumed by relay D2 in releasing plus that time taken by the marker to establish a new call allows the trunk in the called office time to release. This gives protection against the reselection of a trunk while the call is in the process of releasing.

If the called subscriber disconnects, but the calling subscriber does not, only the CS and T relays will release in the tandem trunk.

Group Busy

The PB lead to the traffic register circuit is common to a group of trunks. The operation of either the D-1 or T relays removes the ground from the PB lead for an individual trunk. When all trunks of a group have removed ground a register is operated in the traffic register circuit.

DIAL PULSE TRUNK CIRCUIT---INCOMING FROM LOCAL OR TOLL OFFICE, SIMPLEX SIGNALING OR COMPOSITE SIGNALING TYPE B.

Purpose

This circuit is used for completing calls incoming on a CX or SX basis from step-by-step or manual offices to crossbar, panel, step-by-step or manual.

Seizure OS-01

When the CX relay in the CX circuit operates, ground over lead "E" through relay (T) normal operates relay (A). Relay (A) operated:

Ground lead "ST" under control of relays (D) and (D2);

Operates relay (CS) with "Z" wiring.

When a sender is attached in response to a signal on lead "ST" ground is connected to lead "CO" operating relay (T). Relay (T) operated:

Releases relay (A);

Removes the condenser from the winding of relay (CS);

Removes ground from lead "PB";

Connects E lead to sender.

The release of relay (A) opens the circuit to relay (CS) with "Z" wiring.

When the call originates with an operator, "Z" wiring is used as it is necessary to extinguish the lamp at the operators position as soon as possible as a preliminary to the start dial signal. When relay (CS) operates relay (S) operates closing battery to lead "M". Battery from the sender over lead "T" is closed to relay (CS) before relay (T) operates and holds relays (CS) and (S) operated. When the sender is ready to receive dial pulses, battery is removed from lead "T" and relays (CS) and (S) release giving the operator a start dial signal. No dial tone is possible in this trunk as there is no connection from the sender tone source to the interoffice conductors. When registration in the tandem sender is done by subscribers directly or through another sender, relays (CS) and (S) do not operate until the tandem sender is attached in order to minimize the danger of false charge. Dial pulses appear as openings of the ground which has been held on lead "E" since the origination of the call and are recorded in the sender.

Selections

When registration of the office code is completed ground from the marker through the sender and sender link is connected to lead "DC" and relay (F) operates. Relay (F) operated:

Extends lead "D" to lead "TRL" of the trunk link and connector circuit. Connects leads "S" and "SL" of the trunk link and connector circuit.

Closes ground to leads "M" and "ML" for operating the select magnets.

Estends its own operating circuit to the trunk link and connector circuit.

Upon completion of its functions the marker releases relay (F), releasing the trunk link and connector. The trunk and office link switches are held from ground on relay (T). The sender completes its selections over leads "FT", "FR" and grounds lead "D" operating relay (D). Relay (D) operated:

Closes the ring conductor from the line and balance coils to the trunk link switches:

Operates relay (D1).

Relay (D1) operated: "V" wiring

Removes ground from the winding of relay (CS);

Closes the tip conductor from the line and balance coils to the trunk link switches;

Operates relay (D2).

Relay (D2) operated:

Signals the sender over lead "DC". Closes the final holding circuit for the trunk link switches.

Ground is now removed from lead "CO" releasing relay (T).

Relay (T) released:

Closes the supervisory circuit around condenser (A);

Removes ground from lead "DC";

Closes relay (A) to lead "E"

Relay (A) operates and holds relay (D) while the sender times a short interval and releases. The sender link releases and breads all connections to this circuit.

Relay (D1) operated: "W" wiring

Removes ground from the winding of relay (CS);

Provides a temporary holding circuit from the trunk link switches between the release of relay (T) and the operation of relay (D2);

Closes the tip conductor from the line and balance coils to the trunk link switches;

Signals the sender over lead "DC".

Ground is now removed from lead "CO" releasing relay (T).

Relay (T) released:

Closes the supervisory circuit around condenser (A);

Removes ground from lead "DC";

Closes relay (A) to lead "E";

Closes the operating circuit for relay (D2).

Relay (A) operates and holds relay (D) while the sender times a short interval and releases. The sender link releases and breaks all connections to this circuit.

Relay (D2) operated:

Locks under control of relay (D1);

Closes the final holding circuit for the trunk link switches.

Supervision

When reversed battery supervision is received from the terminating office, relay (CS) operates operating relay (S). Relay (S) connects battery to lead "M" in place of ground thus transmitting the supervisory signal to the originating office.

Disconnection

Disconnection at the originating office results in the removal of ground from lead "E" releasing relay (A).

Relay (A) released:

Releases relay (D);

Removes ground from relay (CS) if relay (S) is released.

Relay (D) is released:

Opens the loop toward the called office;

Restores the repeater termination if used:

Releases relay (D1).

Relay (D1) released:

Closes ground to the winding of relay (CS);

Closes lead "PB";

Releases relay (D2).

Relay (D2) released:

Releases the trunk link and office link hold magnets;

Closes lead "ST" in preparation for a new call.

Relay (D) is slow in releasing to hold over dial pulses or momentary opening due to key operation at the distant switchboard. Relay (D2) is slow in releasing to hold the sleeve (link switches) busy for a short time after the trunk conductors are open. This time plus the time used by the marker to set up a new call prevents the trunk at the distant office from being reselected before it has completely restored. With "V" wiring if the (D2) relay does not operate it will cause the sender to time out.

TRUNK CIRCUIT---OUTGOING TO INFORMATION DESK

Purpose

This circuit is used in establishing connections bewteen a tandem office and a central desk operator or an official P.B.X.

Seizure---When Senders Are Arranged To Send Heavy Positive Pulse Figs. 1 And A

When this circuit is seized ground is connected to the sleeve, and the tandem sender makes trunk test. Relay (A) operates on the trunk test closure, operating in trun relay (B). Relay (B) closes a circuit for operating relay (C) which locks to ground on the sleeve and closes ground to the windings of relays (D) and (G). When the sender opens the trunk test circuit, the (A) relay releases, allowing relays (D) and (E) to operate. Relay (E) operating, releases relay (B).

Reverse Battery

The operation of relay (D) reverses the windings of relay (A) thus connecting "reverse battery" to the trunk. When the sender connects "reverse battery", the (A) relay operates, operating relay (F). When the sender opens the "reverse battery" circuit relay (A) releases allowing relay (G) to operate in series with relay (F). The operation of relay (G) operates relay (G1), which in turn releases relays (D) and (E).

When Senders Are Not Arranged To Send Heavy Positive Pulse - Figs. 1 And B

Seizure

When this circuit is seized ground is connected to the sleeve and the tandem sender makes trunk test. Relay (A) operates on the trunk test closure, operating relay (C), which locks to ground on the sleeve and connects ground to the winding of relay (G). When the sender opens the trunk test circuit, relay (A) releases, allowing relay (G) to operate in series with resistance (A). Relay (G) operating, operates relay (G1).

Talking

The operation of relay (G1) closes the trunk through for talking and gives answering supervision to the originating operator provided the call was handled by an operator before reaching the tandem office. If the call was originated by a dial subscriber, the operation or relay (G) applies the windings of relay (H) to the trunk in the non-charge direction. Relay (H) operates on trunk closure and operates relay (H1). Relay (H1) locks under control of the (C) relay, connects the T and R leads of the trunk through to condensers (A) and (B) ~~and~~ applies the winding of the (A) retard coil to the outgoing trunk.

Disconnection

When the associated trunk circuit removes ground from the sleeve, relay (C) releases, releasing in turn relays (F), (G) and (G1), (Figs. 1 and A) or relays (G) and (G1), (Figs. 1 and B) and relay (H1) if operated. Opening of the T and R leads from the trunk circuit releases relay (H) if operated, on a call originated by a dial subscriber. The circuit is then normal.

OVERFLOW TRUNK CIRCUIT

Purpose

This circuit is for use in a tandem office to hold trunks which are involved in overflow conditions and to send overflow tone and flashes to the originating subscriber or operator.

Description of Operation

General

The tandem marker directs the connection to an overflow trunk when all the desired trunks are busy so that the calling subscriber or operator may be informed of all the paths busy condition.

In those areas where tone only is required Fig. 2 and 3 should be provided. In areas where both tone and a flashing signal (to operators) is required Figs. 1 and 2 with W and Z wiring should be provided. Where flashing only is required Figs. 1 and 2 and W wiring should be provided.

Crossbar tandem trunks respond to a called subscriber receiver off the hook polarity of battery on the ring lead. In step-by-step areas the receiver off the hook polarity is battery on the tip lead. Consequently when crossbar tandem is located in a step-by-step area the tip and ring leads are reversed between the tandem office link frame and the main distributing frame. When this trunk is cross-connected through such a main distributing frame S wiring must be used.

Circuit Operation

When the trunk advances to the talking position, the (A) relay in Fig. 1 operates in series with the trunk conductors. The (A) relay operated, operates relay (A1) when the (B) contact of interrupter (FL) closes. The (A1) relay operated:

Locks to ground on the "S1" lead of the trunk; closes the (FL) interrupter to relay (A2).

Relay (A2) operates when contact (F) of interrupter (FL) closes and performs the following operations:

Locks under control of relay (A1); transfers the (B) contact of interrupter (FL) to relay (RV).

Battery from the (FL) interrupter operates and releases relay (RV), which causes the operator's supervisory lamp at the distant end to flash. Relay (RV) also interrupts the tone in synchronism with the flashes ("Z" wiring and apparatus). The combination of the (BR) retardation coil and the (FT) and (FR) condensers reduces the acoustic shocks toward the calling end to a minimum on each operation and release of relay (RV) ("V" wiring and apparatus). If the motor which drives the interrupters should stop, relay (RV) might remain operated to the back contact of interrupter (FL) and continue reversed battery to the trunk long enough to cause a false registration to the line message register. Relay (MS) is operated from the motor stop circuit by way of the miscellaneous and auxiliary alarm circuit, removing battery from relays (A1), (A2) and (RV) which release insuring that battery is connected in a normal direction.

Fig. 3 is used when tone only is desired. When the trunk is picked by the marker due to an overflow condition the T is closed through the (T1) condenser, through the secondary of the (T1) repeat coil to the R, forming a dry circuit.

The (T) interrupter closes a ground through the primary of the (T1) repeat coil, through A1 condenser to the LT4 tone supply. This induces the tone in the secondary of the repeat coil.

The (T) interrupter will have 60 I.P.M. (rated special) in areas where the Paths Busy Signal is 60 I.P.M. and 120 I.P.M. in areas where the Paths Busy Signal is 120 I.P.M.

Busy Conditions

When Fig. 1 is used the (RV) relay operated puts a ground on the S1 lead to make this trunk busy.

When the Interrupter Frame motor stops, a battery is put on the MS lead to operate relay (MS) in Fig. 2 to make this trunk test busy to the marker.

In order that battery and ground be properly poled with respect to the crossbar tandem trunk supervisory relay when the overflow trunk is connected to an office secondary multiple which is intended for connection to SXS only, options T & S are provided. Option T is to be used when the overflow trunk is connected to terminals intended for connection to crossbar or panel offices. Option S is to be used when the overflow trunk is connected to terminals intended for connection to step-by-step offices.

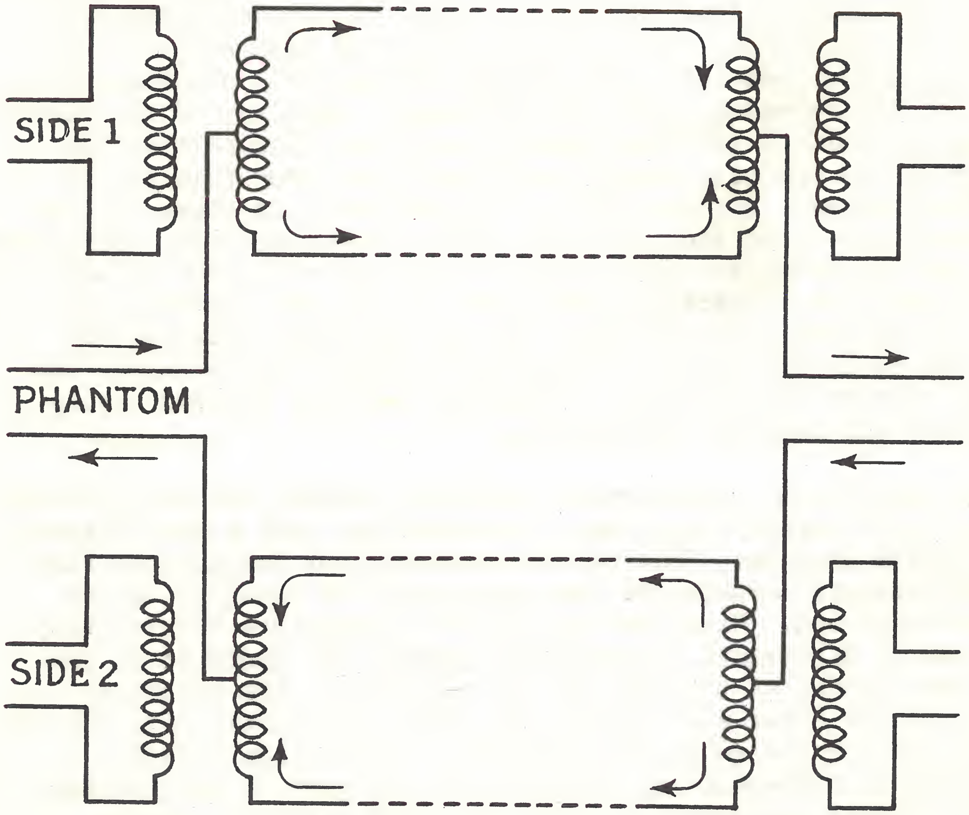
THE PHANTOM CIRCUIT

Figure No. 2 is a simplified diagram of two adjacent and similar telephone circuits arranged for phantom operation. By means of repeating coils installed at the terminals of the wire circuits, a third telephone circuit is obtained. This third circuit is known as the phantom and utilizes the two conductors of each of the two principals, or "side" circuits, as one conductor of the third circuit. The two side circuits and the phantom circuit are together known as a phantom group. These three circuits, employing only four line conductors can be used simultaneously without interference with each other, or without crosstalk between any combination, provided the four wires have identical electrical characteristics and are properly transposed to prevent crosstalk.

The repeating coils employed at the terminals are designed for voice-current and ringing-current frequencies, and do not appreciably impair transmission over the principal or side circuits. The third or phantom circuit is formed by connecting to the middle points of the line sides of the repeating coil windings as shown in the figure. Since the two wires of each side circuit are identical, any current set-up in the phantom circuit will divide equally at the mid-point of the repeating coil line windings. One part of the current will flow through one-half of the line winding, and the other part of the current will flow in the opposite direction through the other half of the line winding. The inductive effects will be neutralized, and there will be no resultant current set-up in the line side of the repeating coil. Since the phantom current divides into two equal parts, the halves will flow in the same direction through the respective conductors of one side circuit, and likewise return in the other side circuit. At any one point along a side circuit, there will be no difference of potential between the two wires due to current in the phantom circuit, and a telephone receiver bridged across them will not detect the phantom conversation.

Since there is no connection, inductive or otherwise between the two circuits at the terminals, it is equally true that a conversation over a side circuit cannot be heard in the phantom. This can be understood by imagining a flow in the closed side circuit through the line wires and the windings of the repeating coils at each end. With the side circuit conductors electrically equal, there can be no difference of potential between the midpoint of the repeating coil line winding at one end and the midpoint of the repeating coil line winding at the other end because the drops of potential for the two parts of the side circuit are equal and opposite. If the side circuit, therefore, impresses no difference of potential on any part of the phantom circuit, the side circuit conversation cannot be heard over the phantom.

In order to prevent the phantom circuit from interfering with the side circuits it is very important that the side circuit line wires (Tip and Ring) be identical. For instance, the d-c resistance of the tip must be the same as the d-c resistance of the ring. Also, for proper phantom operation, all four wires of the group must be identical. In actual practice slight differences of resistance are permitted for practical reasons. This condition where the wires of side 1 and side 2 are identical is called phantom balance.



PRINCIPLE OF THE PHANTOM CIRCUIT
FIGURE 2

TYPES OF SUPERVISION

There are three distinct types of supervision control, the "through supervision", the "repeated supervision" and "CX supervision". An accompanying sketch Fig. 3 shows the fundamental supervision features of each and illustrates the difference between them.

It will be noted that with the through supervision trunk the circuit which holds the connection during talking includes the trunk conductors in and out and the equipment at the originating, intermediate and terminating points. Consequently the supervision range may be limited by the originating or terminating office equipment.

With the repeated supervision trunk and with the CX supervision trunk, on the other hand, the holding circuit for the tandem trunk is independent of the holding circuit for the completing trunk. Consequently this type of trunk has a greater range and a greater freedom from false disconnects as well as other advantages.

Through Supervision Trunk

The through supervision trunk circuit is suitable for intra-city customer dialed traffic from crossbar and panel office (except for remote control zone registration traffic from panel). It can be used for calls terminating in crossbar, panel or PCI manual offices either direct or through sender tandem.

There are certain limitations to the use of the through supervision trunk under conditions other than those just enumerated. It can be used for calls to step-by-step offices only if the outgoing trunks to step-by-step are equipped with trunk circuits (pulse repeaters). It can be used for completion over composite signaling trunks only if the CX sets are in the same building with the tandem equipment.

Assistance calls dialed or keyed by DSA operators through their dialing or key pulsing districts can also be routed over the through supervision trunks with the same restrictions noted for customer dialed calls.

The disconnect relay arrangement of this trunk is designed to approximate the speed-of-release requirements of the crossbar and panel local office incoming trunks.

Each trunk circuit is mounted on a 23-inch mounting plate as a single circuit unit. Sixty trunks may be mounted on a trunk frame.

These trunk circuits should be used with revertive pulse tandem senders only. They are tested by means of a portable test set.

Repeated Supervision Trunk

The non-zone repeated supervision trunk may be used for all purposes for which the through supervision trunk is suitable and is required for several other types of traffic. It should be specified for all loop signaling trunks incoming to tandem from manual, toll and step-by-step DSA boards and trunks from step-by-step offices equipped with senders. It should also be specified for direct trunks to tandem (skip-district) from crossbar and panel DSA boards. Where CX (or SX) operation is desired into tandem and the CX sets are not in the tandem office building auxiliary circuits associated with the CX sets are required to convert the CX signaling to loop signaling and this trunk circuit should be specified at the tandem office.

Each trunk circuit is mounted on a 30-1/2-inch mounting plate as a single circuit unit. Sixty trunks may be mounted on a trunk frame.

These trunk circuits will operate with either revertive pulse or dial pulse tandem senders. They are tested by means of a portable test set.

Optional disconnect relays are available to give either a comparatively fast speed-of-release comparable to that of panel and crossbar or panel and crossbar full selector incomings or a somewhat slower speed-of-release comparable to the disconnect time requirements of crossbar or panel "B" switchboard trunks. The faster relay (Fig. B) should be used where the originating end of the trunk circuits appear on panel selector multiple or crossbar switch frames. The slower relay (Fig. A) should be specified for trunks from switchboards and is required for operation with step-by-step fringe office senders.

In addition to the disconnect relay option other apparatus and wiring options are provided as follows:

(a) A choice of repeating coils is offered with inequality ratios when desired.

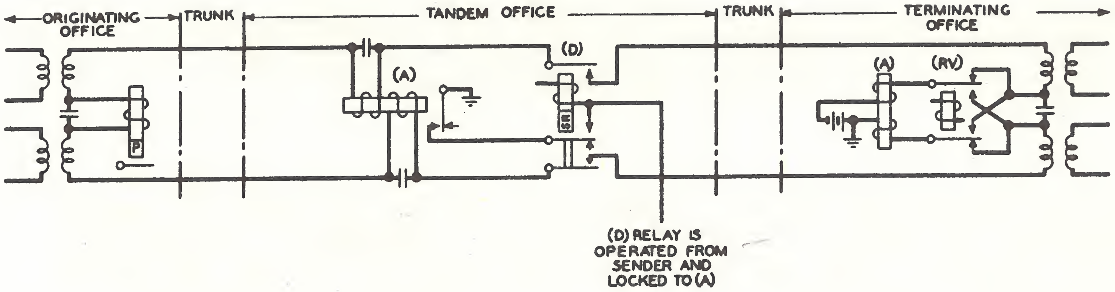
(b) A feature is available ("Y" wiring and apparatus) for balancing impedances during the switching operation on trunks having terminal voice repeaters. Its use on non-repeatered connections with dial pulse tandem senders does not interfere with normal operation.

(c) The trunk may be wired for use with DSA boards and toll boards expecting start dialing signals ("X" wiring) in which case a "receiver-off-hook" condition is encountered when the trunk is selected followed by a "Receiver-on-hook" condition when the sender is attached and remaining this way until the called party answers, or they may be wired for customer dialing from step-by-step in which case a momentary reversal followed by dial tone when the sender is ready will be sent. Trunks may be reversed at the cross-connection on the main frame to give the correct polarity to the connecting office. ("V" and "W" wiring.)

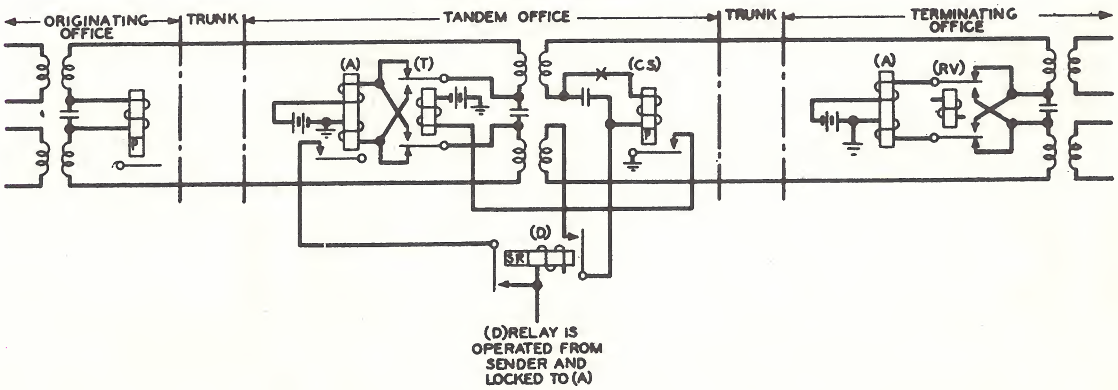
Composite Signaling Trunk

Where the incoming composite sets and coils (or the simplex equipment) are in the same building as the tandem office, no auxiliary circuits are required and the CX or SX equipment and repeating coils are wired directly (6 wires per trunk) to the tandem CX trunk circuit.

THROUGH SUPERVISION



REPEATED SUPERVISION



CX SUPERVISION

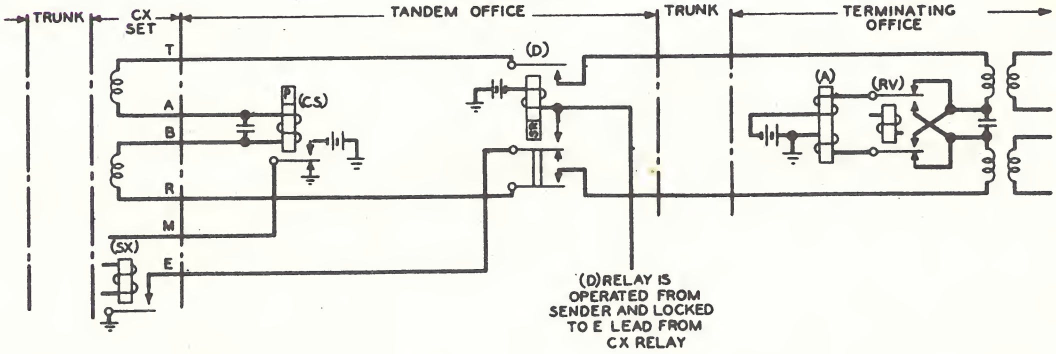


FIGURE 3

TYPE OF SUPERVISION CONTROL
TANDEM TRUNK CIRCUITS

TYPES OF SIGNALING

Loop-Signaling normally given over a pair or wires where pulsing and supervision are obtained by combinations of opening and closing the loop, reversing the battery and ground and marginal currents.

Simplex

Sometimes it is desirable to obtain a single wire facility by means of repeat coils connected at the ends of a circuit. Such an arrangement is represented by one-half of Figure 2. The single wire facility obtained in this manner is known as a "simplex". This type of facility can be obtained from the two wires of a circuit, or from the four wires of a phantom group, as shown in Fig. 4.

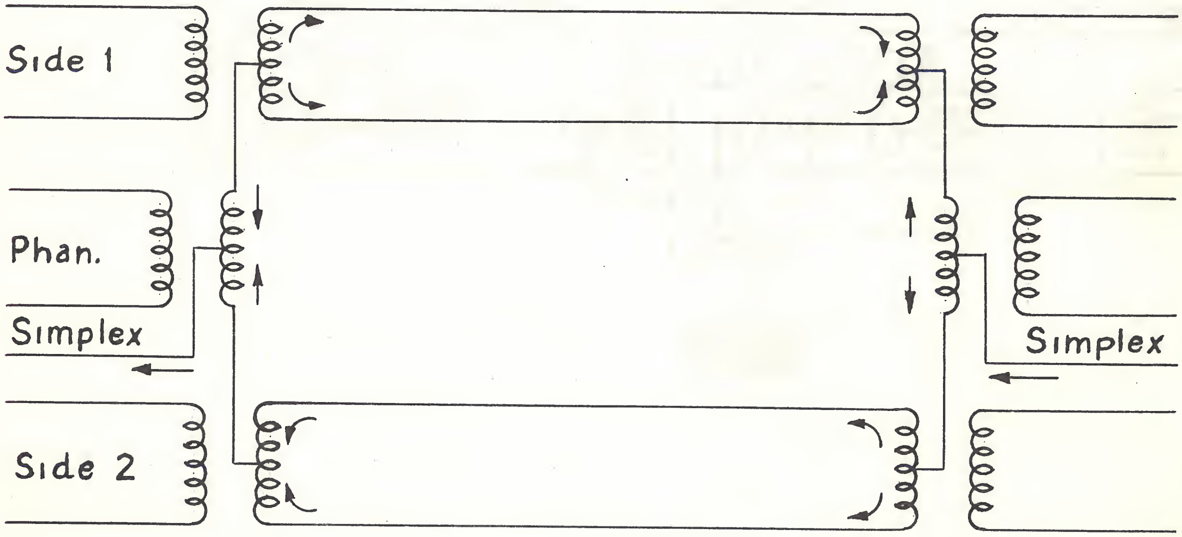


FIGURE 4

SIMPLEX ESTABLISHED ON PHANTOM GROUP

Composite

This describes the operation of the required circuits for a phantom group on a composite signaling basis, as used with crossbar tandem dial pulse senders.

The incoming repeated and through supervision trunk circuits were used on the basis of loop signaling. Loop signaling normally employs a pair of conductors over which pulsing and supervision is obtained by combinations of opening and closing the loop, reversing battery and marginal currents. Such facilities are unsuitable for phantom operation because they introduce signaling difficulties on through connection and on dialing trunks, and do not provide simultaneous two-way signaling. For this reason composite signaling is provided in phantom operation.

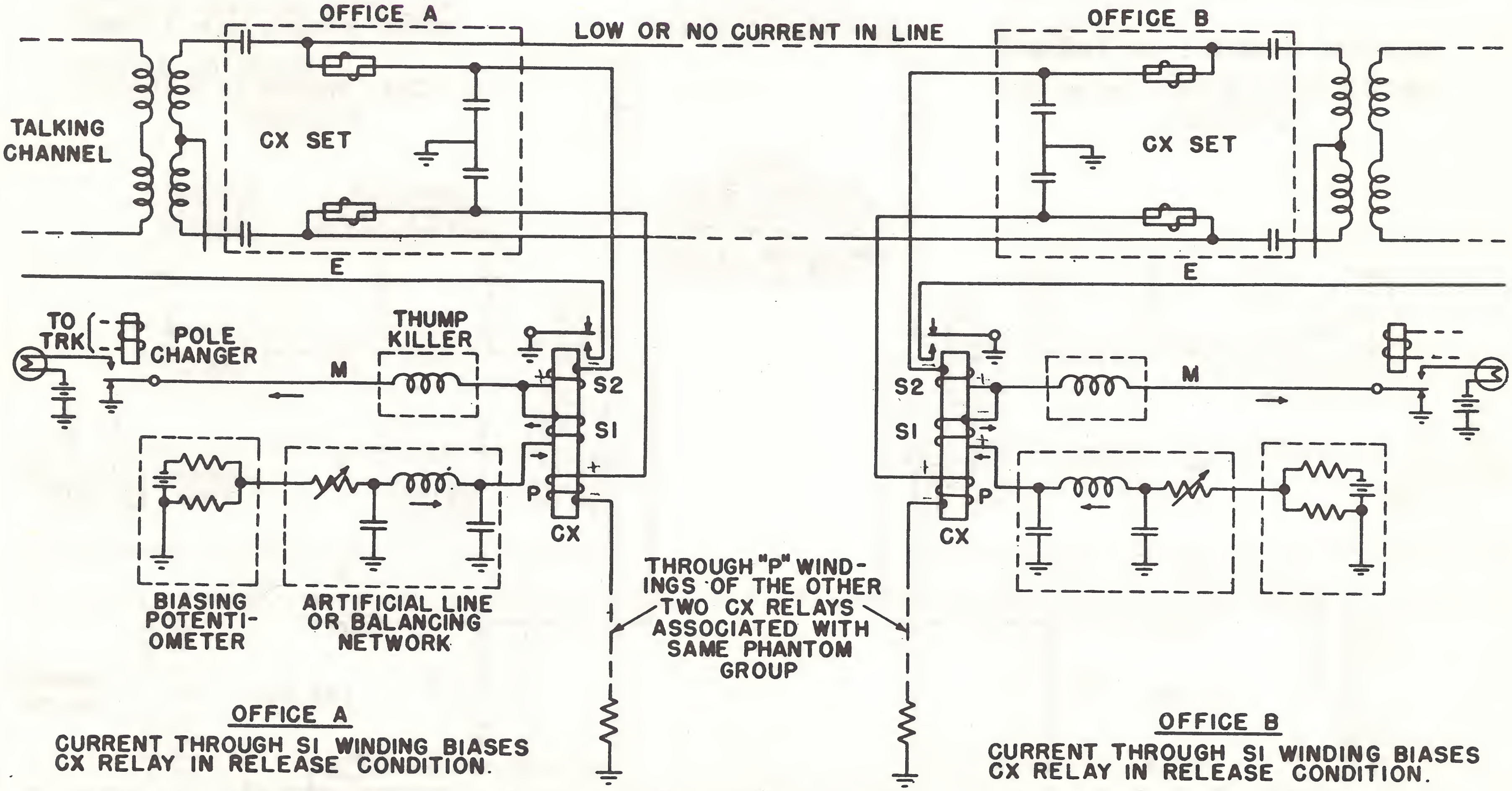
Theory Of Operation

The arrangement which permits d-c signaling on a composited phantom group is shown in figure 5. The two physical circuits, known as the side circuits and having repeating coils at each end, and the third or phantom circuit is derived by connecting the third repeating coil at the midpoints of the repeating coils of the two side circuits. The composite set connects to four d-c signaling channels from the two side circuits by sets of retard coils and condensers. These form a filter to keep the d-c and low frequencies out of the voice circuits, and the voice out of the signaling channels, but the d-c signals may be transmitted independently over each wire of the physical circuits. In this way four d-c signaling channels are used for each phantom group. This gives a signaling channel for each side circuit and the phantom and a fourth that may be used to neutralize differences in earth potential at the two ends of the line.

For signaling and pulsing purposes, each circuit of the phantom group is provided with a CX relay at each end of the line, arranged as shown in Figure 6. These relays have three windings but one of them is employed for earth potential compensation and need not be considered in the explanation of the signaling circuit itself. The two signaling windings S1 and S2 have the same number of turns and are connected differentially. One is connected to the composite signaling channel and the other to a biasing potentiometer through an artificial line, which has characteristics approximately the same as the line itself, so that current builds up and decays in the two windings at the same rate. The other ends of the two windings are connected together and to a lead, marked **M**, to the armature of the pole-changing relay, which is used for signaling and pulsing. The "thump killer" shown in the M lead in the diagram prevents the signal and dial pulses from affecting the telephone circuit.

Assume, for example, that a call is made from office A. Before the operator plugs into the trunk, current flows from the biasing potentiometer through the artificial line and the S1 winding to ground at the pole-changing relay. This biases the CX relays to their released positions because at the same time the S2 windings are short-circuited by the grounds on the break contacts of the pole-changing relays. When the operator plugs into the trunk at office A, current flows through her pole-changing relay, which operates. This causes current to flow in the S1 winding of her CX relay in the opposite direction and tends to operate the relay, but at the same time current now flows in the S2 winding, tending to release the relay; and because the voltage at the biasing potentiometer is higher than ground, the current through S2 is enough greater than that through S1 to hold the relay released. However, the current in the S2 winding flows out over the upper wire of the line and through the S2 winding of the CX relay at office B. Here, because of its greater value, it overpowers the effect of the current in the S1 winding and operates the CX relay. The operation of the CX relay, in turn, causes other relays not shown to prepare the circuit for dialing or repeating the supervision.

If the circuit is arranged for dialing, then when the operator starts to dial, her dial alternately makes and breaks the current to her pole-changing relay. Whether the pole-changing relay at office A is released or operated, the CX relay at this office will remain released; in one case because of the current in S1, and in the other because the current in S2 is greater than that in S1. The CX relay at office B, however, will operate and release with the pole-changing relay at office A, as already described.


OFFICE A
LOW OR NO CURRENT IN LINE
OFFICE B
TALKING CHANNEL
CX SET
CX SET
E
E
TO TRK
POLE CHANGER
M
THUMP KILLER
S2
SI
P
CX
+
-
M
S2
SI
P
CX
BIASING POTENTI-OMETER
ARTIFICIAL LINE OR BALANCING NETWORK
THROUGH "P" WINDINGS OF THE OTHER TWO CX RELAYS ASSOCIATED WITH SAME PHANTOM GROUP

OFFICE A

CURRENT THROUGH SI WINDING BIASES CX RELAY IN RELEASE CONDITION.

LOW OR NO CURRENT IN S2 WINDING.

LOW OR NO CURRENT IN P WINDING. EQUAL TO CURRENT IN S2 WINDING.

OFFICE B

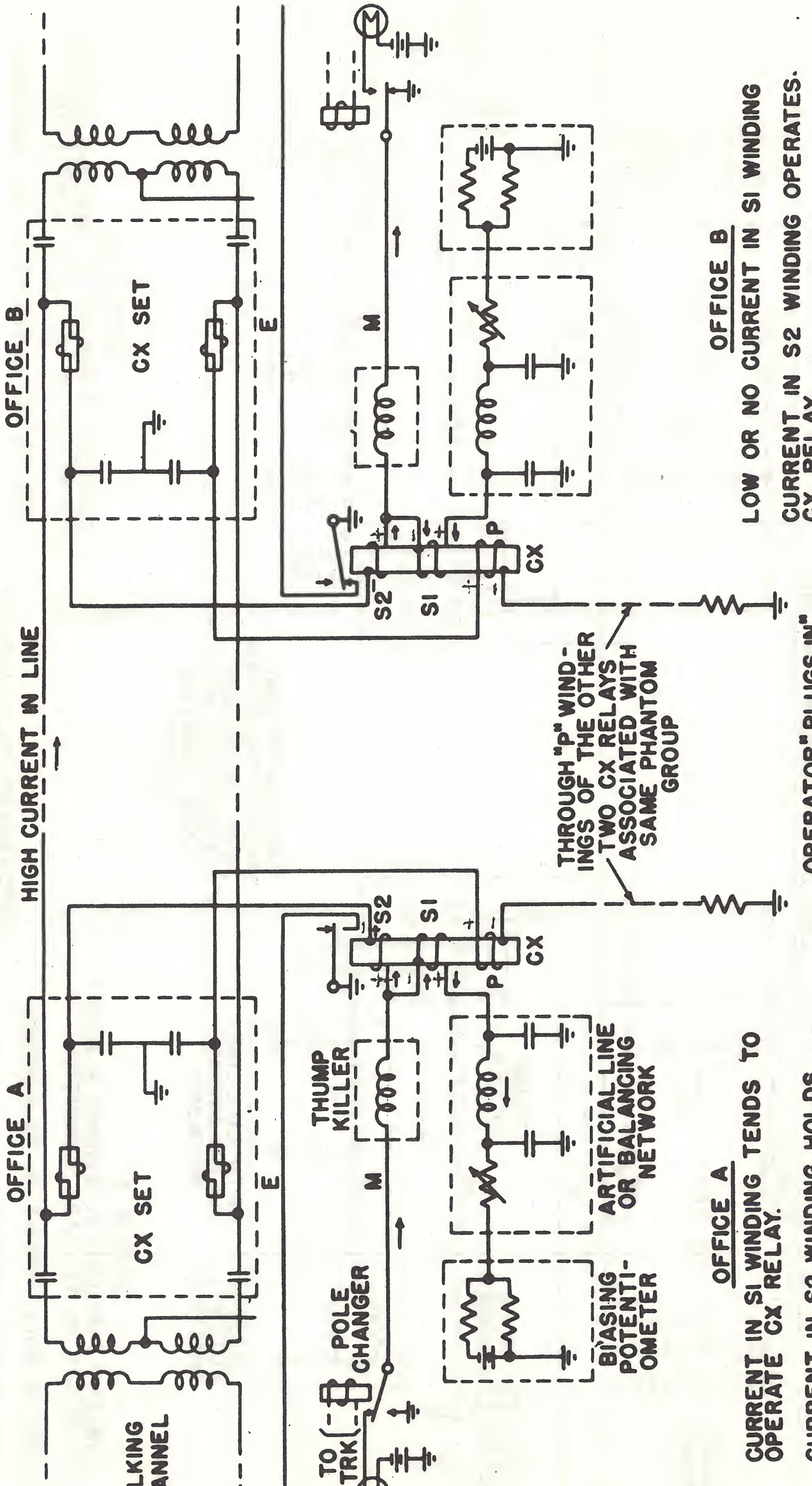
CURRENT THROUGH SI WINDING BIASES CX RELAY IN RELEASE CONDITION.

LOW OR NO CURRENT IN S2 WINDING.

LOW OR NO CURRENT IN P WINDING. EQUAL TO CURRENT IN S2 WINDING.

CONDITION OF "IDLE CIRCUIT"

FIG. 2A



OPERATOR "PLUGS IN" AT OFFICE A

OFFICE A

CURRENT IN SI WINDING TENDS TO OPERATE CX RELAY.

CURRENT IN S2 WINDING HOLDS RELAY IN RELEASE CONDITION

LOW OR NO CURRENT IN P WINDING

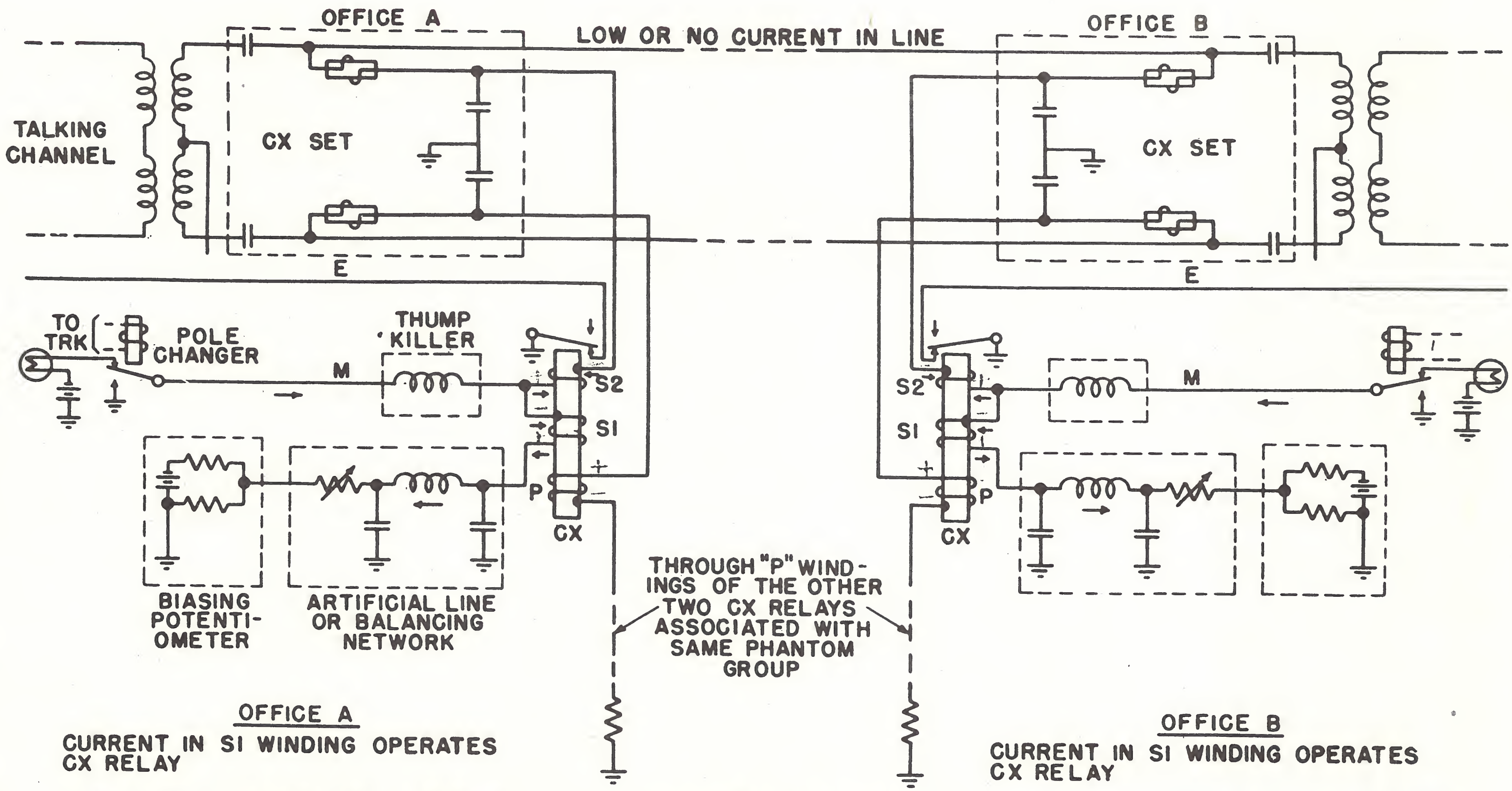
OFFICE B

LOW OR NO CURRENT IN SI WINDING

CURRENT IN S2 WINDING OPERATES. CX RELAY

LOW OR NO CURRENT IN P WINDING.

FIG. 2B


OFFICE A
LOW OR NO CURRENT IN LINE
OFFICE B
TALKING CHANNEL
CX SET
CX SET
E
E
TO TRK
POLE CHANGER
THUMP KILLER
M
M
S2
S1
P
CX
+
−
S2
S1
P
CX
+
−
BIASING POTENTIOMETER
ARTIFICIAL LINE OR BALANCING NETWORK
THROUGH "P" WINDINGS OF THE OTHER TWO CX RELAYS ASSOCIATED WITH SAME PHANTOM GROUP

OFFICE A

CURRENT IN S1 WINDING OPERATES CX RELAY

LOW OR NO CURRENT IN S2 WINDING.

LOW OR NO CURRENT IN P WINDING. EQUAL TO CURRENT IN S2 WINDING.

SUBSCRIBER ANSWERS "OFF HOOK" AT OFFICE B

FIG. 2C

OFFICE B

CURRENT IN S1 WINDING OPERATES CX RELAY

LOW OR NO CURRENT IN S2 WINDING

LOW OR NO CURRENT IN P WINDING. EQUAL TO CURRENT IN S2 WINDING.

Single Frequency-Signaling With Multi-Frequency

This type may be used on trunks of any length. One frequency (1600 cycles) is used in each direction on four wire line circuit. If a single pair is used, two frequencies (1600 cycles and 2000 cycles) are used one from each end. When the circuit is idle the signals from both ends are on the line. If one end originates a call the signal from that end is removed. When the distant office answers, the signal at the other end is removed from the trunk. Either end in disconnecting will connect the frequency signal back on the trunk giving the disconnect signal at the far end.

SEQUENCE OF OPERATIONS DURING A TYPICAL CALL

S.F. SIGNALING DIAL PULSING

ORIGINATING END					CALLED END			
OPERATION	LAMP	M	E	TONE	TONE	E	M	OPERATION
IDLE	—	GND	OPEN	→	←	OPEN	GND	IDLE
SEIZE TRUNK	—	BAT	OPEN		←	GND	GND	
	▨	BAT	GND			GND	BAT	TRUNK CIRCUIT RETURNS "DELAY DIAL" SIGNAL
	☼	BAT	OPEN		←	GND	GND	TRUNK CIRCUIT RETURNS "START DIAL" SIGNAL
PULSING	☼	INT. BAT	OPEN	→ →	←	INT. GND	GND	
	☼	BAT	OPEN		←	GND	GND	AWAIT SUBSCRIBER ANSWER
	▨	BAT	GND			GND	BAT	SUBSCRIBER ANSWERS & TALKS
	☼	BAT	OPEN		←	GND	GND	SUBSCRIBER HANGS UP
DISCONNECT & IDLE	—	GND	OPEN	→	←	OPEN	GND	IDLE

INCOMING TRUNK - SINGLE OR TWO RATE REMOTE CONTROL ZONE REGISTRATION

PURPOSE OF CIRCUIT

This circuit is used to provide means for connecting two trunks whose combined length is greater than the selection capabilities of the connected circuits or where traffic does not warrant a permanent connection. A means for controlling the charging of a local panel district from this trunk is provided.

DESCRIPTION OF OPERATION

GENERAL

When a call is to be completed thru crossbar tandem requiring remote control zone registration this trunk is selected at the Panel office. This trunk circuit then functions to associate itself with a trunk link and controller circuit which in trun picks a tandem sender. When the subscriber's sender has transferred sufficient information to the Tandem Sender a tandem marker is attached. The marker obtains information from the sender and then sets up the connection to an outgoing trunk to the distant office. The tandem sender then performs its functions to complete the call in the distant office and advances this trunk to trunk closure. This trunk circuit is capable of repeating supervision from the incoming trunk in the called office to the calling office. When the called subscriber answers this trunk circuit times the call and sends signals back to the calling end to operate the calling subscriber's line register. This circuit is arranged so that Terminals "27", "32" and "34" may be connected in various combinations to lead "T", "IT" and "N" to give timing intervals of one to five minutes for the initial and overtime intervals. The timing is under the control of a 15 sec. interrupter providing a maximum of 5 minutes per interval using positions 11, 23 to 44 of the (T) selector. To shorten this interval certain of the selector positions are passby as shown in the following table of typical connections for initial intervals of 3 & 5 minutes and overtime intervals of 1, 2, 3 & 5 minutes.

Initial Interval		Overtime Interval				
Time	Selector Positions Pass-By	Time	Selector Positions Pass-By	Connect Terminal "27" to lead	Connect Terminal "32" to lead	Connect Terminal "34" to lead
5 Min.	None	5 Min.	None	T	T	T
5 Min.	None	3 Min.	34 to 41	T	T	IT
5 Min.	None	2 Min.	29 to 32 34 to 41	T	IT	IT
5 Min.	None	1 Min.	25 to 28 29 to 32 34 to 41	IT	IT	IT

Initial Interval		Overtime Interval				
Time	Selector Positions Pass-By	Time	Selector Positions Pass-By	Connect Terminal "27" to lead	Connect Terminal "32 to lead	Connect Terminal "34" to lead
3 Min.	34 to 41	1 Min.	25 to 28 29 to 32 34 to 41	IT	IT	N
3 Min.	34 to 41	2 Min.	29 to 32 34 to 41	T	IT	N

This circuit is also arranged by means of Terminals "4", "6" & "10" connected to the "CH", "IC" & "N" leads to give various number of registrations of the line register both for the initial and the overtime registration. A maximum of 5 registrations has been provided in each interval in positions 2, 4, 6, 8 & 10 of the (T) selector. The number of registrations in any interval is reduced by preventing the MR relay and consequently the line register to operate in positions 4, 6, 8 & 10 of the (T) selector. The following table shows some typical connections and the registrations obtained.

Initial Interval		Overtime Interval				
No. of Registrations	MR is Operated in Selector Positions	No. of Registrations	MR is Operated in Selector Positions	Connect Terminal "4" to lead	Connect Terminal "6" to lead	Connect Terminal "10" to lead
1	2	1	2	N	N	N
2	2,4	1	2	IC	N	N
3	2,4,6	1	2	IC	IC	N
4	2,4,6,8	1	2	N	IC	IC
5	2,4,6,8,10	1	2	IC	IC	IC
5	2,4,6,8,10	2	2,4	CH	IC	IC

SEIZURE - OS 02-1

When a distant subscriber sender is connected to this trunk, battery through the (A) relay winding and its shunt allow trunk test; the (A) relay is marginal and remains non-operated. The subscriber sender advances to office brush position and lowers the resistance of the loop allowing relay (A) to operate. The "ST" lead is now grounded. The associated sender link and controller functions to attach a tandem sender. Relay (T) operates from the sender removing battery and ground from the trunk.

OPERATING SWITCHES

After sufficient information has been transferred to the tandem sender a marker is attached which grounds the "DC" lead operating the (F) relay.

Relay (F) closes several circuits as follows:

Closes the sleeve to the "SL" lead to the marker for testing continuity;

Operates the primary select magnet;

Operates the (LC) relay of the trunk link and connector;

Closes a lead from the marker to the sender for use in signaling after the direct connection through the marker connector is broken;

Operates the ODD or EVEN select magnet;

Closes lead (HC) to the marker;

Operates relay (F1) (two rate reserve only).

The marker, when satisfied with the condition of the switches, releases the (F) relay and checks that the sleeve ground from the front contact of the (T) relay is capable of holding the connection then releases. The (T), (R), (FT) and (DR) conductors are connected directly to the sender with no bridged apparatus in the trunk.

TRUNK CLOSURE

The sender grounds the (D) lead when selections are complete operating relay (D), which performs the following operations:

Closes the trunk toward called office;

Removes a short circuit from one winding of the repeating coil;

Removes ground from the ring conductor toward the originating office - effective after relay (T) releases;

Removes a short circuit from the battery side of the filter;

Closes ground from relay (T) on lead "DC" to the sender;

Provides a locking circuit for relay (CH);

Removes the noninductive shunt on the "S" winding of relay (A).

Upon receiving ground on the "DC" lead the sender removes ground from the (CO) lead releasing relay (T).

Relay (T) released:

Closes battery to the tip and ground to the ring conductors;

Closes the operating circuit for relay (D1);

Removes ground from lead "DC".

Relay (D1) operated:

Closes a holding circuit for the switches;

Closes its own locking circuit under control of relay (D);

Prepares a second operating circuit for relay (T);

Opens the start lead which is also open at relay (D);

Starts the timing relays;

Removes ground from the armature of relay (T) which was used to close lead "DC";

Prepares a circuit for starting the charge when relay (T) operates.

When trunk closure takes place, the (A) relay operates through the filter and coil and provides a signal over lead "D" for the release of the sender. The connection is now controlled by relay (A). The filter consisting of condenser, resistances and retard coil between the battery supply and relay (A) is used to suppress noise due to switching on relays (MR), (MR1) and (MR2) and to provide a holding circuit for relay (CS) of the associated district during switching.

SUPERVISION

Battery reversals from the incoming trunk in the called office cause the (CS) relay to operate and release. Each operation of relay (CS) is followed by the operation of relay (T). Relay(T) when operated with relay (D1) operated causes a similar reversal of the trunk toward the calling office thereby repeating the supervision.

CONTROL OF INTERRUPTERS - OS 02-1, 02-2

Relays (IB) and (IF) operate and release in synchronism with the (B) and (F) contacts of the (CH) interrupter.

Relay (TS) operates as soon as any associated (D1) relay operates and closes the following circuits:

Start leads to the charge timing interrupter;

The 22 volt 60 cycle supply to the 2A timer;

Ground to a contact of the 2A timer;

Relay (M) to the charge timing interrupter.

The (TM) relay now operates and releases under control of timer (T) while relay (M) operates and releases in response to closures and opens from the charge timing interrupter circuit.

REGISTRATION FOR INITIAL INTERVAL - SINGLE RATE OPERATION - OS 02-1, 02-2, 02-3

Relays (T) and (D1) operated, close a circuit which, with the (IB) relay operated and selector (T) normal, operates relay (I). Relay (I) locks to the (T) and (D1) relays and when relay (IF) operates relay (CH) operates and locks to relay (D).

Relay (CH) operated:

Transfers the winding of relay (MR) to ground on the selector which is normal;

Closes ground to termanal 1, arc 5 of the selector;

Short circuits the selector interrupter contact preventing any false steps;

Closes a circuit to hold relay (T) while the selector is between terminals 2 and 10 inclusive;

Closes the registering potentials to relay (MR).

Ground is now connected under control of a set of contacts on relay (M) to the winding of the selector magnet (STEP). The selector magnet operates when relay (M) operates. When relay (M) releases the magnet also releases and at the same time advances the brush assembly associated with arcs 1, 3 and 5 from position 1 to position 2. In position 2, a circuit is closed from battery on resistance (C) to relay (MR) thus operating this relay. The selector advances from position 2 to position 11 under control of arc 5 and relay (M). As the selector leaves position 2, relay (MR) releases. Relay (MR) may operate as the selector passes over terminals 4, 6, 8 or 10 of arc 1 depending upon the manner in which leads "IC", "N" and "CH" are connected. These connections, of course, are governed by the requirements of the zone involved.

Each time relay (MR) operates it causes the operation of relays (MR1) and (MR2) in sequence. Relay (MR1) removes the normal talking battery and shortly thereafter relay (MR2) connects first a positive battery to the tip and then a lower positive battery to the ring. This combination of voltages will produce the necessary loop current for holding the supervisory relay of a connected district and in addition will cause that circuit, when arranged for such service, to operate the line message register. At the end of a registration closure relay (MR) releases removing the charge voltage followed by the release of relay (MR1) which restores the regular battery supply. Relay (MR2) now releases in preparation for any additional pulses. The filter, consisting of a retard coil and associated network, allows any changes to take place slowly enough to prevent noise on the connection.

TIMING OF INITIAL INTERVAL - SINGLE RATE

The selector advances to position 11 by ground pulses supplied by relay (M) under control of arc 5. In position 11 the selector awaits the first ground closure by relay (TM) which supplies the 15 second pulses. When relay (TM) operates it will be operated for an interval during which relay (M) will operate and release at least once. Thus with relays (TM) and (M) both operated a circuit is closed under control of arc 5 and contacts on relays (TM) and (M) in series to operate the selector magnet. Whichever relay releases first will open the circuit to the selector magnet thus advancing the selector to position 12. From position 12 through position 22, the selector is advanced under control of arc 5 and relay (M). Relay (TM) will have released before the selector arrives in position 23 so that the selector must await in position 23 for the next operation of relay (TM). Thus on the next operation and release of relay (TM) the selector advances to position 24 under control of arc 6. The selector advances in the same manner from position 24 to position 25. The selector advances through positions 25 to 32 inclusive and 34 to 41 inclusive either under control of relay (M) of relay (TM) depending upon the manner in which leads "IT", "N" and "T" are connected at arc 4. These connections are made in accordance with the requirements of each zone. Leads "T" and "IT" are connected to the winding of the selector magnet as a safeguard against grounded leads which would otherwise cause regular timing positions to be passed by under control of relay (M). Instead grounds on those terminals which are connected to leads "T" and "IT" are detected since the selector magnet will fail to release thus preventing its progress.

Thus ground which is supplied under control of arc 4 to the contacts of relay (M) will advance the selector over the associated positions at the rate of approximately .88 second per position. In all other cases, the progress of the switch is controlled by arc 6 and is at the rate of 15 seconds per position.

OPERATION OF OVERTIME RELAY (OT)

When position 43 is reached, ground is supplied by arc 2 to relay (OT) operating this relay.

Relay (OT) operated:

Locks under control of relay (CH);

Changes the conditions of registration and timing to those required for the overtime intervals;

Prepares the circuit for passing from position 43 under control of arc 4 and relay (M) for all overtime intervals;

Prepares the circuit for advancing from position 44 under control of arc 6 and relay (TM).

The selector advances through positions 42 and 43 under control of arc 4 and relay (M) at the rate of approximately .88 second per position. The selector advances from position 44 under control of relays (OT) and (TM) and arc 6.

REGISTRATION AND TIMING FOR OVERTIME INTERVALS - OS 02-3

The registration and timing for any overtime interval is the same as for the initial interval except that relay (OT) is operated during all overtime intervals and as mentioned previously the registration and timing conditions for any overtime interval are controlled by the connections of leads "IT", "T", "IC", "N" and "CH". Thus registration impulses will be supplied by relay (MR) in position 2 and in positions 4, 6, 8 and 10 depending upon the zone requirements of the call being served. Similarly, timing of 15 second intervals will be recorded in positions 11, 24, 33, 44 and in positions 25 to 32 and 34 to 41 depending upon the zone requirements of the call being served.

REGISTRATION FOR TWO RATE OPERATION

The operation is the same as described for single rate except that the connections to selector (T) depend on the position of relay (HC) which may or may not operate from the marker while relay (F) is operated.

DISCONNECT

When the trunk is opened at the originating office relay (A) releases followed by the release of relay (D). Relay (D) is slow to release so that any momentary opening of the (A) relay contacts will not cause a false disconnect.

With relay (D) released:

The trunk toward the called office is opened to release the circuits in that office;

One winding of the repeat coil is short-circuited;

Ground is connected to the ring conductor toward the originating office;

A short circuit is placed on the battery side of the filter;

Ground is removed from the winding of relay (CH);

Connects the noninductive shunt around the secondary winding of relay (A);

Releases relay (D1).

The (D1) relay releases after an interval designed to allow the distant trunk to release before the busy condition is removed from the sleeve.

Relay (D1) released:

Releases the trunk and office switches;

Removes ground from the "TS" lead;

Closes the "ST" lead.

Relay (CH) released:

Closes a protective ground to the winding of relay (MR);

Releases relay (OT);

Removes the registration battery in case disconnect occurs during a charge pulse.

SECOND TRIAL

If for any reason the marker circuit cannot establish a satisfactory connection between the incoming trunk and an outgoing trunk, it connects ground to lead "TRL" via the trunk link and connector as a trouble release signal to the sender. The marker circuit releases and the sender selects another marker to serve the call. When the new marker is connected the (F) relay is operated releasing any switches which may have been operated on the first trial.

SDR. LK. & CONT.

SDR. LK. & CONT.

SENDER LINK AND CONTROLLER SD-25358

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SENDER LINK AND CONTROLLER CIRCUIT (SD-25358-01)

PURPOSE

The purpose of this circuit is to provide means for connecting trunk circuits to sender circuits.

DESCRIPTION OF EQUIPMENT

The tandem sender link frame is a two bay structure Fig. 1. The left bay mounts two controller circuits and four rows of multi-contact relays. The right bay mounts eight 200 point switches and two rows of multi-contact relays. Its maximum capacity provides for 100 tandem trunks and 80 tandem senders, interconnected by 40 primary-secondary links in a vertical to vertical spread.

The controller circuits which are two separate units of relay equipment, designated "A" and "B", are in an enclosed casing on the left bay. The "A" unit is in the bottom portion of the casing and the "B" in the top portion.

Above the controllers are four rows of multi-contact relays, five in each row. The bottom two rows are designated HA-0 to 4 and HA-5 to 9. The top two rows are designated HB-0 to 4 and HB-5 to 9. These multi-contact relays are used in pairs as trunk group connectors. A pair consist of an HA and HB relay of the same number to connect a group of ten trunks to either the "A" or "B" controller respectively.

The eight crossbar switches mounted on the right bay are 200 point 4 wire type, the bottom four being designated primary and the top four designated secondary. The 4 primary switches and the 4 secondary switches in their respective groups are divided into an "A" and "B" group of two switches each, indicating which switches are controlled by the "A" or "B" controller.

The horizontal levels of each two verticals in the four primary switches are multipled in pairs and divided into ten groups of four verticals each in the two "A" switches and ten groups in the two "B" switches. The bottom primary switch is designated "A" and has the "A" groups No. 0 to No. 4. The second primary switch designated "B" and has the "B" groups No. 0 to No. 4. The third and fourth primary switches are designated "A" and "B" respectively and have the "A" and "B" groups No. 5 to No. 9.

There are 100 trunks associated with each tandem sender link frame. These trunks start with the lowest numbered trunk in the office and appear consecutively on the tandem sender links. The trunks are called to the "A" group primary switch horizontals in 10 groups of 10 trunks each and multipled to the "B" primary switch horizontals. With this arrangement each trunk has an identical appearance in both the "A" and "B" controllers. It is necessary that all the trunks in a group of ten be of the same type. A tandem trunk requires the closure of eight leads to a tandem sender. Since 4 wire switches are used, two sets of crosspoints are closed to gain the eight connections required. This is the purpose of arranging two pairs of verticals in each group, thereby giving two sets of horizontals for each trunk.

Connected to the horizontals of the 4 secondary switches are 80 tandem senders. This is made possible by splitting the secondary switch horizontals. This is done in the following manner: Secondary switch horizontals are invariably split between the 9 and 10 verticals. The half switches created are again split. In this case the split is guided by the number of trunk groups of each type (dial pulse and M.F. pulse) appearing on the tandem sender link frame. For example, a sender link has 40 dial pulse and 60 M.F. pulse trunks. In this case the half switches created by the 9 and 10 vertical split will be split at the 3 and 4 verticals.

The left half of each switch will be designated 0 or 1 and the right half of each switch 0' or 1'.

With the secondary switches split in the manner described previously there will be 40 senders connected to each controller or 80 in all.

The No. 0 subgroup of 5 senders will be connected to the 0 to 4 horizontals of the verticals 0 to 3. The No. 1 subgroup of 5 senders will be connected to the 5 to 9 horizontals of the verticals 0 to 3. In the same manner No. 2 and No. 3 subgroups will be connected to the same horizontals on the No. 1 secondary switch. Subgroup No. 4 to No. 7 will be connected in the same manner but to the horizontals of the verticals 4 to 9 on each secondary switch. The other controller follows the same pattern with the possibility of having different senders.

Connecting between the primary switch verticals and the secondary switch verticals are 40 links divided into two groups of 20 "A" links and 20 "B" links, each group being served by its own controller circuit Fig. 2. The "A" link group connects between the two primary and the two secondary switches associated with the "A" controller, while the "B" link group likewise connects the switches associated with the "B" controller.

Since it is necessary to connect eight leads between a trunk and sender and in order to do this, two vertical crosspoints must be closed. It will then be seen that a link constitutes two primary and two secondary verticals. As already stated, four primary verticals divided into two pairs are associated with each group of ten trunks. One pair of verticals are designated No. 0 and No. 1, the other pair No. 0' and No. 1'. The No. 0 and No. 0' are a pair of verticals for one link, while the No. 1 and No. 1' are also a pair of verticals for one link, thus there are two links associated with each group of ten trunks. For the purpose of link tracing the numbering is so arranged that the number of the primary switch vertical and the number of the secondary switch to which a link connects is the same.

The No. 0 and No. 1 primary verticals connect to the left half of the secondary switch of the same number, while the No. 0' or No. 1' connect to the right half of the secondary switch of the same number. The trunk group number which a link serves is the same as the number of the secondary switch vertical to which it is connected.

The multi-contact relays above the secondary switches are known as group connectors for the tandem sender subgroups. They are designated C-0 to C-7, one for each subgroup in the "A" group and C-0 to C-7 for the sender subgroups in the "B" group. A C- relay when operated connects all senders within its subgroup to the associated "A" or "B" controller.

Sender subgroups are multipled from frame to frame in a definite pattern to form the sender multiple.

As already stated, one sender link frame serves 100 tandem trunks, divided into ten groups of 10 trunks each, each trunk appearing in both the "A" and "B" groups. By provisional wiring a group of ten trunks can be arranged to prefer either the "A" or "B" controller as first choice. On this basis, each sender link frame is arranged so that trunk groups 0, 2, 4, 6 and 8 prefer the "A" controller, while trunk groups 1, 3, 5, 7 and 9 prefer the "B" controller. Should the preferred controller be busy or in trouble the circuit is so designed that the call gets access to the other controller.

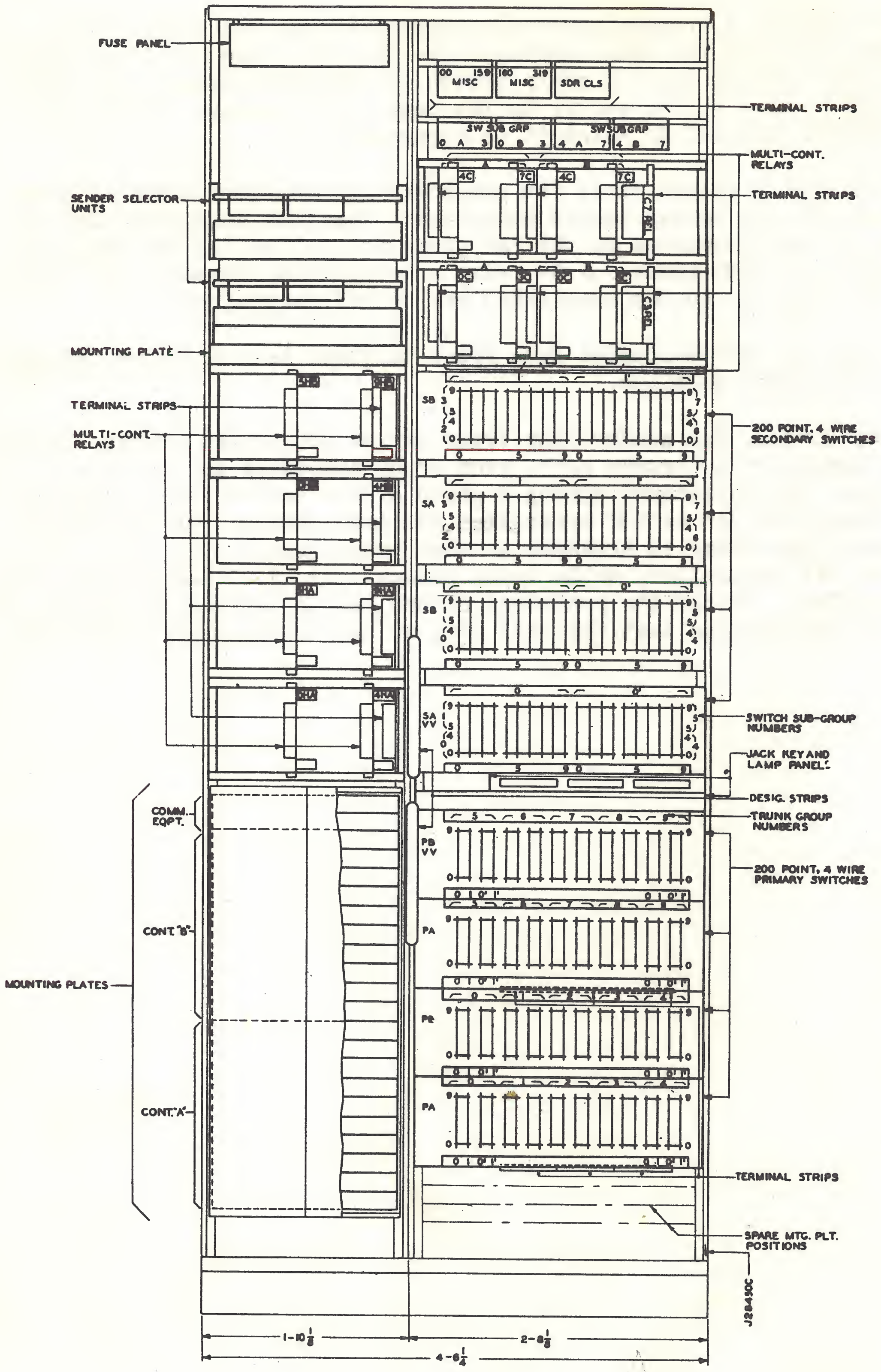
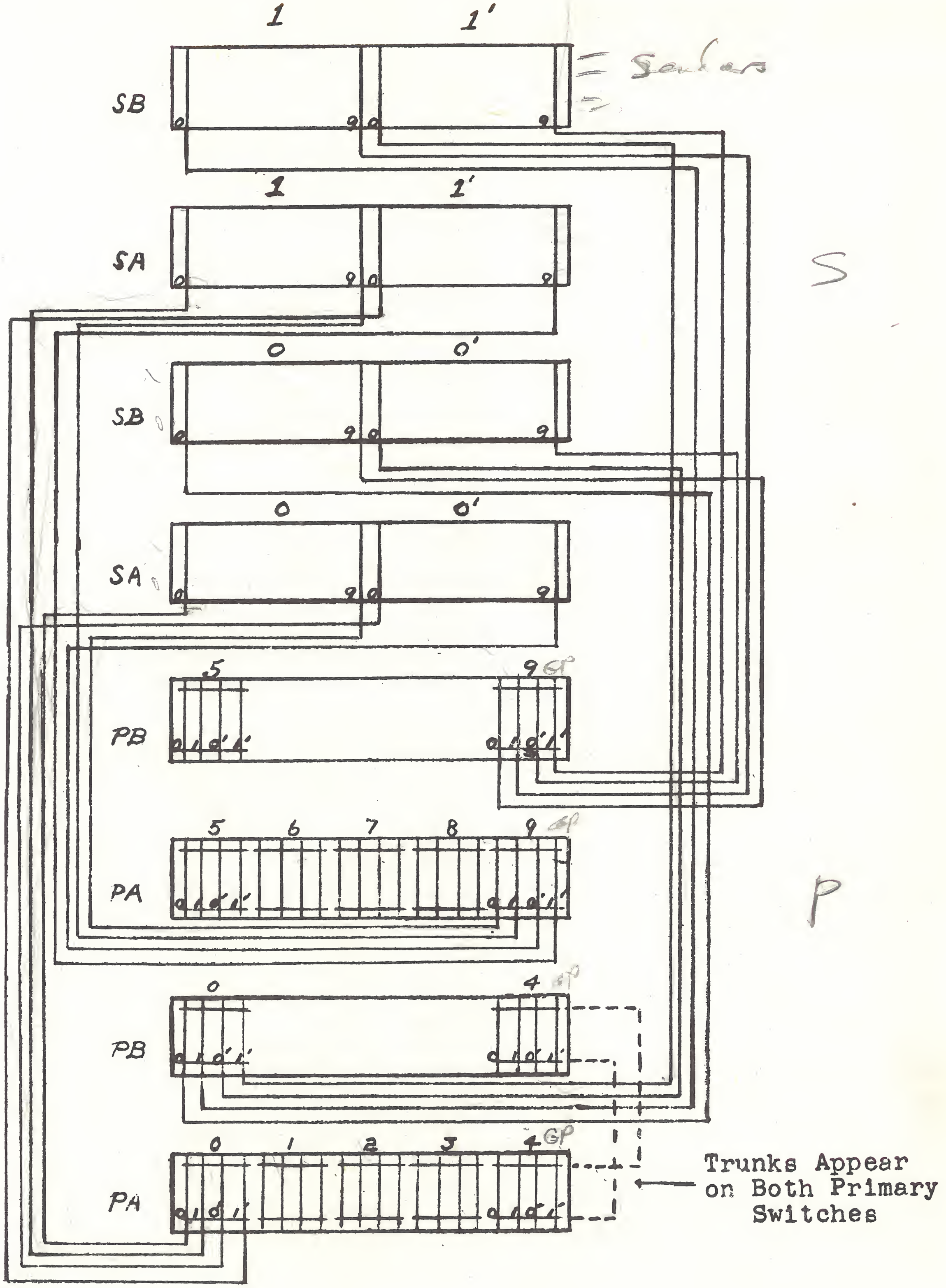


FIGURE 1

SENDER LINK FRAME

3 8-0

TL 12-80



Trunks Appear on Both Primary Switches

FIGURE 2

PRIMARY-SECONDARY LINK SPREAD
TANDEM SENDER LINK FRAME

RELAY DESIGNATIONS - FUNCTIONAL MEANING

AG-0 to 9	"A" Group
AL	Alarm
AR	Alarm Release
BA	Busy "A" Controller
BB	Busy "B" Controller
BG-0 to 9	"B" Group
C-0 to 7	Cut-in (Group of Senders)
CA	Circuit Alarm
CB	Call Block Alarm
D-0 to 9	Divide
G-0 to 9	Group
GB-0 to 7	Group Busy (Sender)
GP-0 to 9	Group Indication
GE	Group End
GS	Guard Sender
HA-0 to 9	Hold "A"
HB-0 to 9	Hold "B"
LA	Links "A" (Idle)
LB	Links "B" (Idle)
LL-0 to 7	Link Lockout
PF	Pending False (Start)
PS	Pending Subgroup (Release)
PT	Pending Termination (Call)
PU	
RA	Release Advance
RL	Release
RS	Reserve Sender
RT	Reserve Test (Senders)
S-0 to 4	Sender
SA	Sender Advance
SA-1	Sender (Cut-in) Auxiliary
SA-2	" " "
SB-0 to 4	Sender Busy
SC-1	Sender Cut-in
SC-2	" "
SG-0 to 3	Sender Group
SGB	Sender Group Busy
SGE	Sender Group End
SL	Sleeve (Secondary)
SS	Sender (Group) Selected
ST	Sleeve Test (Primary)
T-0 to 9	Trunk
TA	Time Alarm
TE	Trunk End
TS	Trunk Selected

SEIZURE OS (94-09)

ST LEAD

The tandem trunk is selected at the distant end, and the A relay in operating, grounds the ST lead to the sender link and controller circuit.

TRUNK GROUP SELECTION

G-0/9

In both the "A" and "B" controller circuits there are ten G- relays designated 0 to 9, for the purpose of indicating to its particular controller which group of ten trunks has originated the call. Each G- relay of the same designation in both the "A" and "B" controllers represents the same ten trunks on the sender link frame. The ten start leads in each group of ten trunks are bunched at the contacts of the D relay and connected to two GS leads, one GS lead to the "A" group links and the other GS lead to the "B" group links.

At the time that the ST lead is grounded by the trunk, none, one or two G- relays may operate for the associated trunk group, this depending upon two equipment conditions. The first condition which the G- relay depends on is that there are idle links in the "A" or "B" link group or in both groups. This is indicated by the GS leads passing through the link hold magnets for the trunk group. The second condition which the G- relay depends on is that there is an idle sender in any of the eight available sender subgroups. This is indicated by the D leads passing through the normal contacts of the sixteen GB- relays. A GB- relay remains normal so long as there is one idle sender in its subgroup or providing the group has not been made busy at the sender make busy frame.

From the above it can be said that a G- relay operated indicates that a link path is available to at least one sender subgroup having at least one idle sender.

GE relay operates following operation of a G relay. CB relay releases following operation of a G relay.

AG-0/9
BG-0/9

Associated with each sender link frame are ten group circuits, each group circuit being a common point of connection to either the "A" or "B" controller. To connect a group circuit to the "A" controller the AG and HA relays are used while to connect the "B" controller the BG and HB relays are used. In each group circuit there is optional wiring "E" and "B" for arranging the preference of either the "A" or "B" controller. As already stated the preference is divided equally between the ten trunk groups. Groups 0, 2, 4, 6 and 8 prefer the "A" controller as first choice and should be provided with "B" wiring. Groups 1, 3, 5, 7 and 9 prefer the "B" controller as first choice and should be provided with "E" wiring. In either case, if the first choice controller is busy, the other controller is preferred.

Only one AG and BG relay can receive preference within the ten groups because the operating battery is chained through the top No. 2 and No. 3 contacts of the G-0/9 relays. The AG or BG relay associated with the lowest numbered G- relay operated received preference.

If the preferred controller is idle, the operation of the associated AG or BG relay causes the G- relay of the other controller to release. For example, if the "A" controller is the preferred controller and the AG relay operates, the associated G- relay in the "B" controller releases. The G- relay in releasing opens the operating path of the associated BG and GE relays. The BG and GE relays are energized and attempt to operate, but because of the fact that their operating path is open as soon as the G- relay releases, they normally lose their energy while still in their released position. The RS relay in the "B" controller does not receive sufficient time to operate during the time that the G- relay is operated, because it is built for slow release factors and this tends to make it slightly slow operate.

GE

As soon as the GE relay is fully operated, the operating paths for all G- relays in the preferred controller are opened, preventing any further calls from indicating a start during this controller operation. The operation of the GE relay is an indication that group selection is ended.

CB

The release of the CB relay grounds the "B" contact of the CB interrupter to start a timing cycle known as the "Call Blocked Alarm," as explained later. As soon as the "B" contact is grounded the PT relay may operate if the interrupter is closed for this contact.

D-0/9

When the D relay operated the ten start lead associated with the trunk group are individualized in preparation for trunk selection. The preferred G- relay loses its operating circuit, but remains operated because of a locking circuit through the make contacts of the AG relay. Any other operated G- relays remain locked to their ST leads.

TRUNK SELECTION

HA-0/9
HB-0/9

There are ten HA-0/9 multi-contact relays and ten HB-0/9 multi-contact relays associated with a sender link frame. These relays serve as connecting links between the "A" or "B" controllers and the trunk groups. Each HA- and HB- relay of the same numerical designation serves the trunk group of the same number. The common control leads for the trunk group, multiple to both HA- and HB- relays, either one connecting these leads to their respective controller when being used for the call.

T-0/9

When the HA or HB relay operated, it connects the ten ST leads of the ten trunks of the group to ten T-0/9 relays for trunk selection. Each grounded ST lead in the group operates its associated T- relay which locks. The operating path is through the released contacts of the TE relay while the locking path is independent of the TE relay.

The T- relays in operating try to remove the shunt grounds from their associated primary select magnets. Only the lowest numbered operated T- can do so. The higher numbered T- relays while removing the shunting ground have it replaced by the next lower numbered T- relay that is operated. These shunting grounds are a precautionary measure to prevent crosses from interfering with calls not requiring the crossed magnets. This is possible because the ten select of the two primary switches of a link are multipled in pairs of the same designation.

GS

The GS relay may or may not operate when the HA or HB relay operates. The purpose of the GS relay is to recheck after the HA or HB relay operates to see whether there is still an available sender. This is necessary since the sender subgroups are multipled to all sender link frames. Should it happen that only one idle sender is available and two calls on two different frames are attempting to connect to this sender group, the frame which selects the sender group first will cause the GB- relay to operate on the other frame. This will cause the GS relay on the frame not getting preference to the sender subgroup to release and wipe out the associated controller, as explained later.

TS

The TS relay operating circuit depends upon the operation of the RS, GS and one operated T- relay. The RS relay will provide its path since it operates before the TS relay and through its normal contacts. The RS relay being slow release insures that the TS relay operates and locks. As already stated, the GS relay may or may not operate. If the GS relay remains operated long enough for the TS relay to get its locking circuit and then release, the controller RL will operate for wipe out, as explained later. The ground for operating the TS relay is from the ST lead of the lowest numbered T- relay operated. If only one T- relay is operated (indicating only one trunk calling in the group) and it releases (on account of the trunk wiping out) before the SS relay operated, the TS relay releases.

TE

The TE relay is provided to open the operating circuits for all T- relays. More than one T- relay may be operated if simultaneous calls are started in the same group; however, any call that is started in the group after the TE relay operated is not registered in the controller circuit because the operating path of the T- relay is opened. The operation of the TE relay indicated the end of trunk selection.

SENDER GROUP SELECTION, REGULAR

SC-1 OR SC-2

The SC-1 or SC-2 relay operated under control of the HA-0/9 or HB-0/9. The type of trunk associated with the HA- or HB- operated will determine which relay will operate. The SC-1 will be operated when sender subgroups No. 0 and No. 3 are used and the SC-2 when subgroups No. 4 to No. 7 are required. These relays cut through the GT and SG leads for the required sender subgroups. The SC- relays are arranged so that the LL lead will be opened if both are operated.

SA-1 OR SA-2

These relays are auxiliary to the SC-1 and SC-2 relays and operate from them respectively. They furnish extra contacts for the purpose of cutting through the proper LL, RT and CG leads. The battery and ground to operate the SA- comes from the associated SC- in order to minimize the possibility of both SA relays operating due to trouble.

LA AND LB

The LA or LB relays or both may operate when the HA or HB relay operates. They operate from ground on the released contacts of the primary switch 0 and 1 hold magnets associated with the trunk group. The function of the LA and LB relays is to close through the four sender subgroups, associated with this call by the operation of the SC-1 or SC-2 relay to the SG-0/3 relays. Each of these relays closes through two sender subgroups for a single indication from one hold magnet keeping in mind that each link has access to two sender subgroups. The even primary hold magnets (0) associated with the trunk group, if normal, operates the LA relay which connects the GT test leads for the two sender subgroups in the even secondary switch to the SG-0 and SG-1 relays. The LB relay will be operated if the odd primary hold magnet is normal, connecting the GT test leads for the two sender subgroups in the odd secondary switch to the SG-2 and SG-3 relays.

SG-0/3

There are four SG- relays designated No. 0 to No. 3 in each controller for indicating what sender subgroups have available senders. There are two facts indicated by the operation of an SG- relay during regular sender group selections. If there is a ground on the GT lead which operates the SG- relay, it indicates that there is at least two senders idle in the group. If the GT lead ground gets through the normal contacts of the GB- relay it is an indication that the sender group is not made busy.

The path for operating an SG- relay is traced from battery through its winding SG lead, operated contacts of SC-1 or SC-2, normal contacts of GB- relay, GB lead, operated contacts of LA or LB relays, normal contact of RT relay. Over the GT lead through the operated contacts of the SC-1 or SC-2 relay, normal contacts of the SGE and SGB relays, T lead, through the normal contacts of at least 2 normal SB relays to ground.

The sender subgroups have a maximum of 5 senders to a minimum of 1 senders per group. Each sender subgroup may have one figure 6, one figure A, one figure C and one to three figure B per unit as required. (SD Figures.)

LL-0/7

There are eight LL- relays designated No. 0 to 7 in each of the controllers "A" and "B", functioning as the link frame lockout relays for the 16 sender subgroups associated with a sender link frame. These relays are provided to establish an order of preference between sender link frames on simultaneous calls, since all sender subgroups have multiple appearances on all sender link frames.

The multiple of sender subgroups is slipped producing a diagonal pattern of connections through successive sender link frame. In order to form the preference chain for a sender subgroup, the LL- relay associated with the sender subgroup location on each frame are wired together as shown in figure D, E and F. The LL- relays forming the chain are not necessarily of the same numerical designation because the sender subgroup may appear as a different numbered subgroup on other sender link frames.

To select a sender subgroup the associated LL- relay is operated, which locks in the SG- relay. The LL- relay to operate depends on the combination of operated SG- relays, the trunk group or groups that are originating calls and the operated SA-1 or SA-2 relay. These combinations affect the PF leads associated with the SG- relays. The LL relay preference is the same throughout all the "A" controllers. The "B" controllers have a different preference in operating the LL. This preference is the same as on all "B" controllers.

The sender subgroup preference for the "A" and "B" controllers is indicated in the following charts:

"A" Controller Sender Subgroup Preference

Trunk Group No.	0	1	2	3	4	5	6	7	8	9
First Choice	0	0	1	1	2	2	2	3	3	3
Second Choice	1	1	2	2	3	3	3	0	0	0
Third Choice	2	2	3	3	0	0	0	1	1	1
Fourth Choice	3	3	0	0	1	1	1	2	2	2

"B" Controller Sender Subgroup Preference

Trunk Group No.	0	1	2	3	4	5	6	7	8	9
First Choice	2	2	3	3	0	0	0	1	1	1
Second Choice	3	3	0	0	1	1	1	2	2	2
Third Choice	0	0	1	1	2	2	2	3	3	3
Fourth Choice	1	1	2	2	3	3	3	0	0	0

Only one LL relay in a controller circuit may operate at any time. However, the LL- relay that operates, is in a chain with LL- relays in other controller circuits which also have access to the same subgroup of senders. More than one LL- relay in the chain may operate at any time. The one electrically nearest to the ground end of the chain, used in locking the SG- relay will have the preference.

SS

The SS relay is operated by the operated LL- relay. The SS relay releases the LA and LB relays if operated. The reason for releasing the LA and LB relays is to prevent changing the selected sender subgroups, if a subgroup nearer the preferred should become available. The SS- relay closes battery for operating the primary select magnet. Connects a holding ground to the GS relay, locks in the TS relay and the preferred T- relay in parallel. It connects ground to the B contact of the SS interrupter. Provides a parallel path to the TS relay contacts for the LL- relay battery. Connects battery which operates the C- relay. The operation of the SS relay indicates that a sender subgroup has been selected.

C-0/7

There are eight C- relays designated C-0 to C-7 associated with each controller for the purpose of connecting any sender subgroup that appears at the tandem sender link to the controller. The number of C relays associated with a sender subgroup depends on the number of appearances that the sender subgroup has throughout the tandem sender links. The C- relays associated with one sender subgroup are multipled together and do not necessarily have the same designation because the sender subgroup location will vary on the different link frames.

Assume that a sender subgroup multiples on the sender link frames as indicated below, the C- relays associated with the subgroup would be formed in a multiple as illustrated.

Sender Link Frame No.	0	1	2	3	4	5	6	7	8
Link Group	B	B	B	B	A	A	A	A	B
Switch Group No.	0	1	2	3	0	1	2	3	0
C Relay No.	0	1	2	3	0	1	2	3	0

The group of secondary switch horizontals (or levels) and the C- relay devoted to a sender subgroup on any sender link frame is called a switch subgroup.

It is possible to have any one of eight C- relays operating from four SG- relays because the operating circuit of the C- relay is under the control of the SC-1 or SC-2 relay.

The wiring of the bottom 1, 2, 3, 4, 5 and 6 contacts and the top 1, 2 and 3 contacts of the SG- relays is for the purpose of maintaining a short-circuit on the windings of the associated C- relays at all times except during the operating period for the one C- relay that will be in preference.

At the time sender group selection is taking place, if two or more SG- relays operate, ground is removed from the CG leads by the closure of the top 1 and 2 contacts, but are immediately regrounded by the closure of the bottom 1 and 2 contacts. When the SS relay operates, releasing all SG- relays except the preferred, the combination of contacts are so arranged that the C- relay of the preferred SG- relay is the only one of the four not short-circuited, but operated by the resistance battery.

At the time a C- relay operates it checks to see that no other SG- relay is operated except its associated SG- relay and that the LA and LB relays are released. Any combination of operated contacts from two or more SG- relays cancels the operating battery and short-circuits those C- relays associated with the SG- relays having their contact closed. This circuit design is to prevent the hazard of having more than one C- relay operated to one controller at any one time.

CS OR AOP LEAD

The C relay in operating will close ground through to the sender on one of the CS-0/4 leads and CS-5 or CS-6 lead. This will be explained in detail when sender operation is studied.

F-0/9 LEAD
F-00 LEAD
F-10 LEAD

When the C- relay operates, a combination of F- leads are grounded to the sender as a frame indication (number of frame), which the sender passes to the tandem marker. The tandem marker uses this frame indication as a means for selecting the trunk link frame which has the originating call.

Since there are a maximum possible 20 trunk link frames in this system, ten F- leads designated 0 to 9 are provided for indicating the units digit of the frame number, one F-00 lead for indicating the first group of ten frames and an F-10 lead for indicating the second group of ten frames. Therefore, two F- leads are used at each sender link frame, one of the F-0 to F-9 with the F-00 or F-10 lead.

The F- leads used in the group F-0 to F-9 on any sender link frame are multipled to each of the eight C- relays on that frame. The F-00 lead is multipled to all C relays on the first ten sender link frame (0 to 9) or that portion of the first ten frames equipped. The F-10 lead is multipled to all C relays on the second ten frames (10 to 19) or that portion of the second ten frames equipped.

The grounds for the frame indication are supplied through the operated contacts of the HA or HB relay operated.

SENDER SELECTION

S-0/4

As soon as the C- relay operates, sender selection takes place to pick an idle sender from the subgroup selected. Associated with each sender in the subgroup is an S- relay and SB- relay, the S- relay being used to select the sender and the SB- relay which is operated by the sender to indicate busy.

The top 3, 4 and 5 contacts of the SB- relays in a subgroup form a preference chain which is directly associated with an S punching on each of the SB- relays. Each of the S punchings in the chain are cross-connected to a P- punching in the group P-0 to P-4, which are associated with the 10 to 14 contacts of the C- relay. The S punching to be cross-connected depends upon what sender is to be first choice in the group. The preference chain works from the highest S- relay to the lowest S- relay.

When a sender subgroup is fully equipped with five senders, the ratio of P- and S- punchings is the same and may be connected in any combination without difficulty. Should a sender have only three senders, it is then necessary to double up on the P- punchings. For example, the P-0 and P-1 punchings could be strapped and connected to the first S- punching, the P-2 and P-3 strapped and connected to the second S- punching and the P-4 to the third punching. Other combinations can be worked.

SC LEAD

When the S- relay operates, it grounds the SC lead to the associated tandem sender, operating the SC-1 relay for moving the sender off-normal. The operation of the sender SC-1 relay causes ground to be returned on the GH lead to the sender link. The GH lead is connected to the HM lead at the contacts of the S- relay.

SGE

When any one of the S- relays operate in a subgroup, it closes a path to operate the SGE relay, which opens the ground from all GT and RT leads, at all sender link frames having the appearance of the sender subgroup. This operation takes the sender subgroup out of preference at all sender link frames, thus preventing the associated SG- relay from operating at any of these frames that may be in sender group selection.

OPERATION OF SELECT MAGNETS

Primary Select Magnet

Connected direct to the ten T- relays in each controller are the primary select magnets of the two primary switches associated with the controller. The ten select magnets of the two switches are connected in parallel and wired to the T- relays. Each pair of select magnets 0 to 9 are connected to the T-0 to T-9 relays respectively. Since the T- relay receiving the preference represents the trunk and its location in the primary switch levels, it controls the pair of primary select magnets associated with the level. While two primary select magnets are operated during one call, only one becomes effective, since only one set of link hold magnets will be operated. The primary select magnet operates as soon as the identification of the called trunk is completed and locked in, that is, when the SS relay has operated.

Secondary Select Magnets

When the preferred S- relay operates, it operates its associated secondary select magnet. The secondary select magnet to operate corresponds to the switch horizontal associated with the sender represented by the S- relay operated.

There are ten secondary select magnets, 0 to 9 in each secondary switch. Since there are two sender subgroups associated with each secondary switch, half of the secondary select magnets 0 to 4 are controlled by one subgroup and 5 to 9 by the other subgroup. The 0 to 4 select magnets of secondary switch zero are controlled by the C-0 and C-4 relays. The 5 to 9 select magnets of this secondary switch are controlled by the C-1 and C-5 relays. Likewise the 0 to 4 select magnets of secondary switch one are controlled by the C-2 and C-6 relays while the 5 to 9 select magnets are controlled by the C-3 and C-7 relays.

When the C- relay operates, a short circuit is placed on each of the five secondary select magnets associated with the sender subgroup. Upon the operation of the preferred S- relay, it removes the short circuit from its associated select magnet in the group of five.

OPERATION OF HOLD MAGNETS

SA

The SA relay operates from ground on the GH lead which connects to the HM lead from the selected sender. When operated, it extends the GH lead ground to operate the four link hold magnets in parallel. The hold magnets to operate are two primary hold magnets corresponding in number to the secondary switch having the selected sender subgroup and two secondary hold magnets corresponding in number to the trunk group having received preference. These four hold magnets operate in parallel.

The SA relay is slow operate to insure that the secondary select magnet is fully operated, before the ground is applied for the operation of the hold magnets. The operation of the SA relay is an indication that the sender has been selected and moved off-normal.

ST

Upon the closure of the crosspoints associated with the primary hold magnet designated 0' and 1', whichever is being used, the operating ground from the GH lead is extended to the operated contacts of the T- relay, to operate the ST relay, as a check of this crosspoint closure. The number of the horizontal crosspoints closed must correspond to the number of the T-relay through which the ST relay was operated, otherwise the ST relay will not receive an operating path.

SL

Upon the closure of the crosspoints associated with the secondary hold magnet designated 0' to 9', whichever is being used, the operating ground from the GH lead is extended to the tandem sender over the S lead. As already stated the sender link connects ground to the SC lead to operate the SC-1 relay in the sender. The sender SC-1 relay in operating connects the S lead of the sender link secondary crosspoints to the SL lead at the contacts of the sender link C- relay. This causes the SL relay to operate as a check on the closure of the secondary switch crosspoints and the continuity of the tandem sender.

GS LEAD

The tandem sender circuits are so arranged that no relay can advance unless the frame indication has been registered and the check of the sender link crosspoints is successful. If these conditions are met the ON-1 relay in the sender is connected to the GS lead. This lead will be grounded from the normal TA relay contacts if the SL and ST relays are operated.

SB

The tandem sender receives ground on the GS lead operating its ON-1 relay as a signal to advance for selections, the ON-1 relay grounds the SB lead to the sender link operating the SB relay associated with the sender, thereby making the sender busy.

The SB relay in operating removes its availability from the chain for indicating two senders idle in the group.

The SB relay in operating, grounds the BS lead to the sender, operating the ON-2 relay in preparation for the release of the sender link controller.

RL LEAD
SL LEAD
S LEAD

The sender ON-2 relay operated grounds the S lead to lock in the sender link primary and secondary hold magnets for the duration of the sender connection. It grounds the SL lead, holding the sender link SL relay until the sender link controller releases. It grounds the RL lead, operating the sender link RA relay in preparation for the release of the sender link controller.

RA

The operation of the RA relay is an indication that the sender has received the frame indication and the code indication satisfactorily. At approximately the same time that the RA relay operates, the trunk T relay is operated to release the A relay and remove ground from the ST lead. To check that the ST lead ground is removed by the time the RA relay operates, the release of the sender link T relay follows after the operation of the RA relay. If the ST lead ground is not removed the T relay fails to release and prevents the release of the controller, as explained later.

RETURN TO NORMAL

RL

The operation of the RA relay releases the operated T- relay which releases the ST relay. The release of the ST relay closes ground from the operated contacts of the RA relay to operate the controller RL relay, causing the controller to release.

When the RL relay operates, it removes the ground supplied by the CB relay from the CB interrupter. The CB interrupter continues to function since it is also receiving ground from the operated contacts of the SA and RT relays until they release.

When the RL relay releases, the resistance battery is applied to the G- relay chain which reoperates the CB relay, providing that there are no other calls waiting to be served, in which case other G- relays would be operated. If other G- relays are operated the CB relay remains released and upon the release of the RL relay, ground the CB interrupter to start timing for the next call. The RT relay having released prior to the RL relay, opens the cycle of timing for the first call.

RESERVE SENDER GROUP SELECTION

The RS relay is slow release to allow sufficient time for regular sender group selection to be completed before the reserve sender group selection is started if required.

When the TS relay operated, indicating that the trunk had been selected, the RS relay began to release. The release of the RS relay operates the RT relay which transfers the windings of the SG- relays from the GT leads to the RT leads. The RT leads receive ground from their associated SGB relay normal. The SGB relay being normal indicates that at least one or more senders are idle in the group.

The reserve sender group selection only becomes effective if no SG- relays operate during regular sender group selection. This delay allows the RS relay to release, operate the RT relay, in turn operating the SG- relays associated with RT leads having ground connected.

If one or more SG- relays operate during regular sender group selection, the LL- relay in operating operates the SS relay which in turn releases the LA and LB relays, disconnecting the winding of the SG- relays from the RT relay before the RS relay is released. Therefore, with the LA and LB relays released and the RT relay operated, the reserve sender selection is cancelled.

TRAFFIC LOCKOUT

Traffic lockout concerns the situation where more than one call is locked into a controller waiting to be served. The ten G- relays of each controller circuit are so arranged that in the event of simultaneous calls, or should any operate before the GE relay operates, those that are locked in are served before others are allowed to be registered. Therefore, no other G- relays can operate after the operation of the GE relay. However, those previously operated and locked to their respective start leads remain operated.

When the controller circuit releases at the end of the first call, the G- relay corresponding to the group being served releases and is unable to reoperate, providing that there is a call waiting in another group, since the other operated G- relays will hold the GE relay operated.

Service is next given to the group corresponding to the next highest numbered G- relay in the chain which is operated. Upon the release of the RL relay, the AG- or BG- relay operates operating the D relay, eliminating the operating time of the G- and GE relays which are already up.

After the last group has been served the operation of the controller RL relay releases the operated AG- or BG- relay which releases the G- relay, in turn releasing the GE relay. When relays RL and GE release all the G- relays may again operate provided calls are waiting in their respective groups.

CALL BLOCKED ALARM

The call blocked alarm circuit is started when the controller CB relay releases, grounding the "B" contact of the CB interrupter and is arranged to allow from a minimum of 5 seconds to a maximum of 12 seconds for a call to be completed. If a call requires more than 5 to 12 seconds, the call blocked alarm functions, causing the frame AL lamp to light, an audible alarm to be sounded, a traffic register to be scored at the sender make busy frame and a white aisle lamp to be lighted.

After the CB relay releases, additional grounds are connected to the "B" contact of the CB interrupter by the GE, RS, RT and SA relays as they operate. The purpose of applying these additional grounds is to maintain a ground on the call blocked alarm circuit until the last relay releases in disconnection. The RT relay being the last relay to remove its ground, also releases the PT relay. The release of the RL relay allows any waiting calls to be served.

A circuit feature is provided for grounding the CB interrupter, should all relays release except the D relay at the completion of a sender link call. Ground is furnished at the operated contacts of the D relay through the associated AG and BG relays released.

A circuit feature is provided for grounding the CB interrupter on the first call through either controller if both "A" and "B" controllers are made busy.

To release the call blocked alarm the AR key (non-locking) is depressed. If at the time the AR key is depressed, the trouble which causes the alarm has reappeared or has not cleared out of the controller the PT relay will be operated, thereby preventing the AL relay from releasing. With the AL relay operated and the AR relay released, ground is applied to the G lead lighting a guard lamp on the floor alarm board and the audible alarm continues to sound.

TRUNK GROUP FAILURE INDICATION

If a call is waiting more than 5 to 12 seconds with a link and sender available, an alarm will sound and lamps corresponding to the trunk groups with calls waiting will light. In this case the operated G- relay or relays will release the CB relay which will supply the ground to the IK interrupter.

Either or both the "A" and "B" controllers being made busy will bring in the alarm when a call is originated and has to wait more than 5 to 12 seconds for completion. In this instance it is not necessary for a link and sender to be available for the alarm to be brought in.

A trunk group which is made busy and has an originating call in it will bring in the alarm.

FAILURE OF CROSSPOINTS TO CLOSE

If the crosspoints fail to close, the circuit functions as on a normal call up to the point where the ST and SL relays should operate from the crosspoint closures. Since these relays fail to operate, the GS lead is held open, the SS relay being operated in its normal sequence causes the SS interrupter to count time and operate an alarm in the same manner as the call blocked alarm.

The range of time covered by the SS interrupter is a minimum of .98 seconds to a maximum of 2.28 seconds. It must be kept in mind that the overall time of 5 to 12 seconds is being counted also during the time that the SS interrupter is counting its time, but since its cycle is much shorter than the overall time, its purpose is to cause an alarm quicker, should there be a delay after the sender subgroup is selected. This allows the sender subgroup to be released to other traffic in a much sooner interval.

When the TA relay operates it causes the same functions that occur when it is operated for the call blocked alarm circuit. When the RL relay operates, it restores the controller circuit to service as on a normal call.

DOUBLE CONNECTIONS

If in controller "A" or "B" any hold magnet of a group becomes crossed to one of any other group or its own group, the first call set up using either group causes both sets of hold magnets to be operated and opens the "PA" leads. The opening of the "PA" lead associated with the hold magnet not being used for the call, removes the corresponding link from service in this second group or its own groups. During the period that these crossed hold magnets are operated, only one link will be available to any calls starting in this second group or none available if crossed in its own group.

A bent selecting finger in front of an 0' or 1' primary hold magnet actuating bar can cause double connections within one vertical providing the trunk associated with the bent finger is not required for the call. In setting up a double connection on a primary vertical, it will cause a feed back on one of the S-0 to S-9 leads associated with the T- relays. The feed back will be on the S- lead connected to the crosspoints associated with the bent finger and receives its ground from the sleeve lead of the secondary crosspoints of the established connection. If a call is started by the trunk associated with the bent finger while engaged in a double connection and providing this trunk receives the preference in the T- relay chain, the controller ST relay is operated prematurely blocking the call. This happens as soon as the T- relays operate for trunk test. The operation of the ST relay prematurely opens the operating path for the S- relay, blocking the call and causing a time-out within 2.28 seconds after the operation of the SS relay.

A bent selecting finger in front of an 0' and 1' secondary hold magnet actuating bar can cause double connections within one vertical providing the sender associated with the bent finger is not selected for the call. In setting up a double connection on a secondary vertical, it will cause a feed back on the S lead of the sender associated with the bent finger but will cause no trouble until this sender is selected for another call during the time that the double connection is existing. Upon the selection of this sender, the sender SC-1 relay connects ground to the SL lead prematurely, causing the controller SL relay to operate. At the same time that the sender SC-1 relay connects ground prematurely to the SL lead, it connects ground in the regular manner to the HM lead, which in a regular call operates the controller SA relay. The SA relay being slow operate, allows sufficient time for the SL relay to open its operating path thereby preventing the hold magnets from operating. This condition causes a time-out within 2.28 seconds after the operation of the SS relay.

Bent selecting fingers in front of an 0 or 1 primary or 0 to 9 secondary hold magnets can not be detected by this circuit. It is anticipated that the number of double connections from these causes will be negligible.

Crossed primary select magnets or secondary select magnets have no effect until it is necessary to operate them for a call. When trunk selection is made the T- relays operated continue to hold ground connected to the M-leads except on the M- lead of the lowest numbered operated T- relay. The

M- lead of the lowest operated T- relay will also have ground connected, if it is involved in the cross, otherwise a cross has no interference with a call. Likewise when the S- relay operates, if its associated S- lead is not involved in a cross there is no interference with the call. When a required select magnet lead is associated with a cross, the applied ground shunts the operating resistance battery preventing it from operating. Either the primary or secondary select magnet failing to operate, prevents crosspoint closure. The hold magnets in operating without one of the select magnets up, prevents the ST or SL relay from operating causing an alarm as explained under "Failure of Link Crosspoints to Close."

GROUNDED START LEAD

At approximately the same time that the controller RA relay operates, the trunk T relay operates to release the A relay and removed ground from the ST lead to the controller, also allowing the sender to function for the call. Should this fail, the call is delayed resulting in an alarm within 2.28 seconds and causing the attached sender to start timing out.

Ground still connected to the ST lead after the RA relay operates prevents the T- relay from releasing thereby blocking the release of the controller. The fact that the hold magnets have been operated and put under control of the sender; and since the shunt or ground on the tip and ring has not been removed by the trunk, the sender is stuck and times out. In the meantime the controller SS relay being operated causes the SS interrupter to time and operate the RL relay releasing the controller and sender subgroup.

Provided that there are no other calls being attempted on this frame, the grounded start lead causes a new start in either controller and results in the premature operation of the ST relay as soon as the T- relay operates if the hold magnets are still operated to the sender which was used on the first attempt. With the ST relay operated, the "P" leads are open and a new sender can not be selected. The first sender eventually times out and a second sender is seized but at no time can this trunk remove more than one sender from service at a time and every attempt is accompanied by a closure of ground to the alarm lead if the alarm relays have been released for any reason.

After a time alarm occurs, resulting from a continuous grounded ST lead, if there are calls waiting to be served in other groups, the GE relay fails to release causing the trunk group with the troubled ST lead to be placed in the traffic lockout sequence. When other calls have been served this cycle occurs again until such time that the trouble is cleared.

FALSE STARTS

If the ST lead is opened after the start of a call and before the TS relay operates and locks the FS interrupter which was grounded by the operation of the HA or HB relay starts counting time. The failure of the TS relay to operate could be due to ground being removed from the ST lead releasing the T- relay, opening the operating ground for the TS relay. It could also be due to the last sender group available being selected by another frame, thereby releasing the GS relay, opening the operating ground for the TS relay.

The FS interrupter times for a minimum of .348 seconds to a maximum of 1.243 seconds for the TS relay to operate and if failing to operate in that time grounds the FS lead to the sender make busy frame to score a traffic register and receive back a release signal over the RL lead, operating the RL relay causing the controller to release.

If a sender and a link path to it is available when the controller is first seized but becomes busy after the TS relay operates and before a sender group is selected, the GS relay releases causing the immediate operation of the RL relay. This condition would have to be considered on the basis that only one sender subgroup was available and it was selected by another frame before this frame made sender subgroup selection. It could be made busy in three ways, one by the operation of the SGE relay in a normal call, by the operation of the GB relay if made busy by the make busy jack or through the last available sender being selected in which case the GB relay is also operated.

After the RL relay operates and releases the controller, the trunk originating the call is then served by the other group of links and controller.

MAKE BUSY FEATURES

Group Busy Jack

A make busy jack GB is furnished per figure 3 to provide means for removing any figure 3 from service for maintenance reasons. These jacks should be considered for emergency use only, because of the fact that unless the trunks are made busy at the originating office there will be stuck senders in the originating office on those calls being attempted during the period that a group is made busy.

Controller Make Busy Jack

When a short-circuited plug is inserted into the controller make busy jack, relay BA or BB operates. Either one of these relays (BA or BB) operated will cause the corresponding GE relay to operate. This prevents the G-0/9 relays from operating routing the calls through the other controller of the pair. The controller will remain out of service until the plug is removed.

Should a make busy plug be inserted into the MB jacks of both controllers then the BA and BB relays will operate, opening the operating paths of the GE relays. This restores the controllers to service. Audible and visual alarms are given in this case until one of the MB plugs are removed. If a call is delayed in this case for more than 5 to 12 seconds the circuit will proceed as for a link alarm.

SENDER SUBGROUP MAKE BUSY

Each subgroup of senders has an MB jack and GB lamp for making the group busy. When a plug is inserted into the MB jack, the SGB relay operates causing all the associated GB- relays on those sender link frames having the sender subgroup appearance to operate. The operation of the GB relays removes the sender subgroup from preference by opening the "PA" leads. The SGB relay in operating lights a group busy lamp GB at the sender make busy frame.

The SGB relay can also be operated when all senders in the subgroup become busy. With all associated SB- relays operated, a chain circuit is closed for operating the SGB relay.

TRAFFIC LOAD REGISTER

Associated with the bottom 6 and 7 contacts of all SGB relays is a 400 ohm and 800 ohm resistance connected into a network to the "CG" lead of the traffic register circuit. As each sender subgroup becomes busy and connects ground to its resistances, the current flow over lead "CG" increases until it reaches the operating value of a relay in the traffic register circuit.

CONTROLLER HOLD JACK

The hold jack HD is provided for maintenance purposes to prevent the timing circuit from automatically releasing the controller circuit, except on false starts. This jack when used opens the operating path of the RL relay from the timing circuit TA relay, thereby allowing the circuit to block at the exact stage where the trouble occurred.

Since this condition requires that the controller circuit be out of service during the interval that the trouble is being observed, it is important that the HD jack shall be used only under close maintenance supervision and never left unattended. This is especially necessary under the situation where the other controller has been made busy. In this case, when the HD jack blocks a call, all other calls are delayed on the frame until such time that the plug is removed from the HD jack.

D. P. SENDER

D. P. SENDER

Chapter 5

DIAL PULSE SENDER SD-25478

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DIAL PULSE SENDER
SD-25478

REGISTRATION

SELECTION OF SENDER - (OS2 - SC-1 unless otherwise indicated)

SC-1

The sender link and controller circuit in its functions selects a sender subgroup and removes it from service on other sender link frames. A group of common leads of the controller are then connected to the subgroup by the operation of the C multi-contact relay for the selection of an idle sender. The idle sender is selected by the operation of its S relay, which connects ground to the SC lead operating the SC-1 relay in the sender.

HM LEAD

The SC-1 relay connects ground to the HM lead to operate the sender link primary and secondary hold magnets thereby connecting the trunk to the selected sender.

S AND SL LEADS

These leads are connected together by the SC-1 relay for the purpose of sleeve continuity check between the link secondary crosspoints and the sender. Operation of the controller SL relay is an indication of continuity.

REGISTRATION OF TRUNK LINK FRAME

The SC-1 relay cuts through to the particular sender a pair of leads designated F-00 and F-10. One of these leads will be grounded by the sender link and controller to indicate the tens digit of the trunk link number. The F-00 will be grounded if the trunk link is numbered under 10 and the F-10 if over 10.

SC-2

This relay cuts into the sender ten leads designated F-0 to 9 to indicate to the sender the units digit of the trunk link frame number. This information is recorded on the sender crossbar switch vertical. The crosspoints being closed at a horizontal of the same number as the grounded F-0 to 9 lead. This information is later transferred to the marker via the marker connector to aid the marker in establishing a connection to the trunk link and connector frame. The operating ground for the F-00 or F-10 relay is extended through the operated contacts of the F-00 or F-10 relay as a temporary off-normal ground.

CLASS OF CALL

The class of call is registered in the sender by operating one of the CS-0 to 4 and CS-5 or 6 relays. The previously mentioned leads, F-00, F-10, F-0 to 9, and CS-0 to 6 are common to a subgroup of five senders, as indicated by the strapping. They can be cut into only one sender at a time, as a relay chain circuit in the sender link controller circuit prevents the operation of the SC-1 and SC-2 relays of other senders of the subgroup while those of one sender are operated.

SELECT MAGNETS

There are ten select magnets numbered 0 to 9 on the sender crossbar switch. The select magnet to operate corresponds in number to the grounded F-0 to F-9 lead. Operation of a select magnet causes the operation of the SM-1, SM-2 and SM-3 relays for the operation of the F hold magnet.

SM-2

The series circuit through the F hold magnet and the SM-2 relay insures that the relay and consequently, the operated select magnet remain operated until the hold magnet is operated and locked.

SM-3

The operating path for the SM-3 relay is traced through contacts of the operated CS-0 to 4, CS-5 or 6 and the operated F-00 or F-10 relay, in order to delay advance of the circuit if either should be slow in operating and to hold the sender link controller circuit, as described later, if either one should fail to operate at all. The SM-3 relay in operating causes the operation and release of the registration advance relays RA-2 to 5.

RA-2 to 5

These relays are operated or released by the operation and release of the SM-3 relay for the previous digit and close a circuit for operating the hold magnet for the digit dialed. (See Chart No. on circuit operation diagram.) The auxiliary CL and HL relay make it possible to use the RA-2 to 5 for operating the eight hold magnets without increasing the number of RA relays.

F HOLD MAGNET

Is an indication that a CS- relay was operated and either the F-00 or F-10 relay was operated. If either of these conditions were not met, the SM-3 relay and consequently, the F hold magnet would not have operated. Crosspoints were closed at the level of the previously operated select magnet.

ON-1

The ON-1 relay in operating checks that frame registration has been made correctly. That only one select magnet was operated and only one of the F-00 or F-10 relays is operated. If two select magnets are operated a path will be provided to operate the CK OS(4-2) relay and prevent the operation of the ON-1 relay. Two CS-0 to 4 relays operated or CS-5 and CS-6 operated will operate the CHK also. Both the F-00 and F-10 relays operated will prevent the operation of the ON-1. With this check made, the sender advances to release the sender link by grounding the RL lead. Operation of the ON-1 relay cuts through the T & R leads in preparation for receiving dial pulses, OS(4-1). Operation of the ON-1 relay is also a further check that the sender link crosspoints were closed. Failure to close the crosspoints would prevent ground from being connected to the GS lead to operate the ON-1 relay. The L relay is placed across the T & R leads in preparation for receiving the dial pulses, OS(4-1).

SR - OS(4-1)

Operates when the ON-1 relay operated to place supervision of the connections under control of the sender. The SR relay is made slow release in order to hold while the L relay is operated down during the open period of a pulse. If the SR relay releases, a disconnect would be registered in the sender, OS(4-1).

ON-2

The operation of the SR-1 relay closed a path to operate the ON-2 relay grounding the RL lead as a release signal to the sender link and controller circuit. Ground is closed through from the BS lead to the S lead. This closure puts control of the sender link hold magnets in the sender keeping the crosspoints closed until the sender advances for disconnection.

RV-1

The RV-1 relay is a condenser timed relay to delay its operation. This condition is required if an origninating step-by-step sender is to be used for the call. It is not required for the "A" switchboard type of call. The operation of the RV-1 relay causes the RV-2 and RV-3 relays to operate. The RV-2 relay reverses the T & R leads as a start dialing signal.

RV-3

The operation of the RV-3 relay applies dial tone to the T & R leads. The tone is closed from the LT-2 lead at the AL-1 relay through tertiary of the TN coil to ground at the SR relay. It is induced into the primary coil and transmitted to the calling "A" switchboard over the operating path of the L relay, as a signal that the equipment is ready to receive dial pulses. The path operating the L relay through the secondary winding is opened. The L relay holds operated over the T & R leads as a continuity check of those leads. If the L relay releases, the sender will disconnect as described later.

DIAL PULSES

Dial pulses are momentary openings in the circuit that are now closed over the T & R loop, and the sender circuit L relay responds to them by releasing and reoperating for each pulse. The pulses are produced by the action of the dial while restoring to normal, so that their frequency and duration may be uniform, which might not be the case if transmitted while the dial is rotated manually. The number of pulses sent is in proportion to the movement of the dial and corresponds to the digit dialed, except that for zero, ten pulses are sent.

ELECTRICAL BIAS OF L RELAY

The primary winding of the L relay is its operating winding, and is connected in series with the line at this time. The tertiary winding, to which ground is connected by operation of the ON-1 relay, provides an electrical bias for the relay. This electrical bias compensates for variations in the voltage of the central office battery, as any increase or decrease in the magnetic field set up by the operating (primary) winding, due to a change in voltage, is counter-balanced by a corresponding increase or decrease in the opposing (tertiary) winding. With this circuit arrangement, there is always approximately the same relation between these two windings, and the operating and releasing properties of the relay are in consequence, not materially affected by fluctuations in voltage. The electrical bias also causes the relay to be "power driven down" on a small reduction in its operating current. For example, if the operating winding provides 100 ampere turns and the biasing winding 90, a drop of only 15 per cent in the line current leaves the current in the bias circuit stronger by 5 ampere turns, forcing the relay to release.

SECONDARY WINDING OF L RELAY

The secondary winding of the L relay, in a circuit with the PH condenser, insures a minimum front contact closure of .012 second and a minimum back contact closure of .009 second, regardless of the percentage make and break of the dial contacts. The minimum front contact closure is provided by the charging current of the PH condenser, after the relay operates, from battery through the secondary winding of the L relay, to ground through the winding of the L-1 relay and operated contacts of the L relay. This charging current is in the operate direction of the L relay and tends to hold it operated until the condenser becomes fully charged, even if the path through the primary winding should be opened before that time. The minimum back contact closure is provided by the discharge of the PH condenser, this action starting as the relay breaks its front contact in releasing. In order to illustrate this action, the charged condenser may be considered as a small storage battery having a very short life, and with the front contact of the relay open, disconnecting ground from this portion of the circuit, the batteries at the L and SR relays have no effect on the circuit as their ground return is open. The fact that the batteries are common, however, and, therefore, connected, is of use in tracing the discharge circuit. It originates at the left hand plate of the PH condenser, which has a positive charge, and is traced through the winding of the SR relay and the DD resistance in parallel, to the battery symbols, thence over the battery bus bar to the battery symbol at the secondary winding of the L relay, through this winding to the right plate of the condenser, which has a negative charge. This discharge current is in the release direction of the L relay. It assists the biasing winding in making the relay fast release and tends to hold its back contact closed until the condenser is fully discharged, even if the operate winding should be energized again before that time.

REGISTRATION OF PULSES - OS(4-1), SC-3, Chart No.

It is assumed that the operator dials at this time. The L relay will follow the opening and closure of the dial contacts and in turn cause the auxiliary L-1 and L-2 relays to operate and release.

L-2

The L-2 relay is a fast release relay for the purpose of insuring a locking circuit for the L-3 relay. This guards against the loss of the first pulse of a digit, which might otherwise occur should the L relay reoperate before the RA relay has operated and connected the locking circuit for the L-3 relay. This condition is created by the RA relay being a slow release relay. In order to be sufficiently slow release, it becomes of necessity slightly slow operate. Hence, without the locking circuit from the L-2 relay, the L relay may reoperate before the RA has operated and release the L-3 relay.

RA - OS(2-1)(4-1)

The RA relay may be slow release to hold over the operations of the L-1 relay while the digit is being registered. The RA relay has its secondary winding strapped, this winding being held to an exact number of turns and its resistance to within plus or minus 3 per cent to hold it to the required slow release time. There is less variation using this means than could be had by using a copper sleeve. When the L relay operates to its back contact on the first open of the digit, the L-3 relay operates and locks. At the closure after the open, the L relay operates to its front contact and allows the shunted L-5 relay to operate. The operated L-5 relay closes a path to operate the P-1 relay which locks through the SM-1 relay normal. The second open pulse will cause the L relay to operate to its back contact and operate the L-4 relay. The L-4 relay opens the locking path of the L-3 relay, releasing it. When the T & R leads are closed again after the second open pulse, the L-4 and L-5 relays release. The L-4 relay will lock through the operated contacts of the L-3 relay until that relay releases. This is to insure the release of the L-3 relay on a short closure of the L relay back contacts. If the L-3 relay failed to release, a pulse would be lost. The L-5 relay normal at the second closure operates the P-2 relay which locks. The above cycle repeats itself for each pair of pulses received. The L-5 relay operated operates the next higher odd numbered P- relay and when the L-5 relay is down, the next higher even numbered P- relay operates, OS(4-1). The RA relay releases during the long closure between digits and operates the RA-1 relay. The released RA relay closes the operating path for a select magnet, the same number as the digit dialed. The P- relays are locked to the SM-1 relay normal to prevent their release until the select magnet is fully operated. The "A" hold magnet operates, as described previously for the "F" hold magnet. The SM-3 relay in operating and releasing for each digit, sets the register advance relays RA-2 to 5 for the hold magnet for the next digit.

AL-1

The operation of the "A" hold magnet causes the AL-1 relay to operate. The dial tone is disconnected by the operation of the AL-1 relay and the timing is recycled as described in detail later.

SM-1

When the SM-1 relay releases, it closes the locking paths for the P relays for the next digit. If dialing of the next digit starts, however, before the SM-1 relay releases, the RA relay operates and the RA-1 relay releases on the first pulse, as previously described, and in this case the RA-1 relay normal provides the locking ground for the P relays until such time as the SM-1 relay releases.

PRELIMINARY IMPULSE - OS(4-1)

The number 1 cannot be recorded on the"A"register as there is no path from the P-1 relay to the No. 1 select magnet until after the"A"hold magnet has operated. The P-1 relay, if operated with the P-6 relay normal is released with the RA-1 relay operates at the end of the first digit to prevent interference with succeeding digits. With no select magnet operated, the circuit does not cut off dial tone and is prevented from advancing to the B register. There is no interference, however, with the registration of a 7, as the P-6 relay operated provides a locking path for the P-1 relay, in turn permitting the No. 7 select magnet to operate. This arrangement is used to prevent registration of the digit one due to some interference before dialing or due to a one being dialed in error for the "A" digit. Any number of such preliminary impulses will be absorbed in the same way, provided that they are far enough apart so that the RA relay releases between them. The"A"digit, when it is received, is recorded on the"A" register whether or not any preliminary impulses are received.

PULSE RELAY TABLE - OS(4-1)

The following table gives the P relays operated due to reception of from one to ten dial pulses. The select magnet operated in each case is of the same number as the digit dialed:

Digit Dialed	Number of Pulses Received	Pulse Relays Operated	Select Magnet Operated
1	1	P-1	1
2	2	P-2	2
3	3	P-3	3
4	4	P-4	4
5	5	P-5	5
6	6	P-5, P-6	6
7	7	P-1, P-6	7
8	8	P-2, P-6	8
9	9	P-3, P-6	9
0	10	P-4, P-6	0

REGISTRATION OF REMAINING DIGITS - OS(2-1)(4-1)

Seven digits are dialed for a full selector call. The first three digits, consisting of the first two letters of the office name and an office numeral, constitute the office code. They are registered on the A vertical of the crossbar switch as previously described for the "A" digit, and on the B and C verticals in a similar manner for the "B" and "C" digits,respectively. These digits control the selection of a trunk to the called office by means of the marker and a distant office selector if required. They also control other functions of the sender which differ for different called offices. The next four digits dialed represent the number of the called line and are recorded on the TH, H, T and U verticals of the crossbar switch, respectively. On calls to manual offices having five digit numbers or party line, a fifth numerical digit or a party letter may be dialed, being recorded on the ST vertical. The pulse relays operated for any digit are as previously given for the "A" digit, and the number of the select magnet operated in each case is the same as the digit dialed. For each digit dialed, relays L to L-5, RA-1 and P-1 to P-6 operate and release as described for the "A" digit, OS(4-1). At the end of the series of pulses for each digit, the proper select magnet is operated, as before, OS(4-1). The SM-1, SM-2 and SM-3 relays operate, functioning as before, and operating the hold magnet for the digit. The SM relay and the operated select magnet release for each digit as described for the "A" digit. Each operated hold magnet locks, OS(2-1). The SM-3 relay, when it operates and releases for each digit, causes register advance relays RA-2 to RA-5 to function, in order to prepare the path to operate the hold magnet for the next digit. Relays CL and HL, operating, assist in closing these paths.

SELECTIONS

RELAYS AND MAGNETS OPERATED - OS(2-1)

At this point in the call the following relays and hold magnets are operated: F-00 or F-10, CS-, CS-5 or 6, ON-1, ON-2, ON-3, AV-3, OF-2, SR, SR-1, L, L-1, L-2, RA-1, AL-1, AL-2, RV-1, RV-2, RV-3, CL, HL, UL-1 and UL-2, hold magnets F, A, B, C, TH, H, T and U. There will not be an ST hold magnet as this is assumed to be a full selector call. The TH, H, T and U hold magnets may be in any stage of operation depending on how far dialing has progressed. The UL-1 and UL-2 relays operate when the units digit is dialed.

MARKER CONNECTOR CIRCUIT

Each sender circuit is wired to a marker connector circuit by about 60 individual leads. The function of the connector circuit is to connect the sender to a marker, which in turn receives the code dialed, class of call and trunk link frame information from the sender, returns the decoded information which the sender requires and closes an outgoing path through the trunk and office link frames. When the office code is dialed, operation of the CL relay causes the following:

INFORMATION FROM SENDER TO MARKER

The operation of the DST OS(4-1) relay connects battery to the ST and CBS leads. This battery causes a group of four multi-contact relays to operate and connect the sender to a marker. The sender transfers to the marker the number of the trunk link frame involved by means of the F-0 to 4, F-00, F-10, FA-5 and FB-5 leads. The three digits of the office code are indicated by means of the B-0 to 4, BA-5 and BB-5 for the "A" digit, D-0 to 4, DA-5 and DB-5 for the "B" digit, G-0 to 4, GA-5 and GB-5 for the "C" digit. The class of call is indicated to the marker by the CS- leads. The trial is indicated by the TR-1, TR-2 and OF leads.

INFORMATION FROM MARKER TO SENDER - OS(4-1)

The marker transmits the required information to the sender by grounding a selection of leads to operate the correspondingly designated selection register relays in the sender. These relays may be released and reoperated in a different pattern if the marker should be unable to find an idle trunk and an idle path to it on the original routing, and should consequently, reroute the call. The sender relays operated at this time are given in the following sections, as applying to all classes of calls.

OFFICE BRUSH - OS(4-1)

The OB- relays will be operated if the call is required to route through a distant two-wire office selector or through a second tandem office on a revertive pulse basis. When a distant two-wire office selector is used, the selections 0 to 4 only will be required for use. If a second tandem office is involved, the selections 0 to 9 may be made. In the case of a second tandem office, the office brush selection in conjunction with the office group selection is used as the office code.

Office Brush	Selection Register Relays Operated OS(4-1)
0	None
1	OB-1
2	OB-2
3	OB-1, OB-2
4	OB-4
5	OB-5
6	OB-5, OB-1
7	OB-5, OB-2
8	OB-5, OB-2, OB-1
9	OB-5, OB-4

OFFICE GROUP

Office group selection, when required, is controlled by the OG relays, operated as follows:

Office Group	Selection Register Relays Operated OS(4-1)
0	None
1	OG-1
2	OG-2
3	OG-1, OG-2
4	OG-4
5	OG-5
6	OG-1, OG-5
7	OG-2, OG-5
8	OG-1, OG-2, OG-5
9	OG-4, OG-5

SKIP OFFICE - OS(4-1)

The SO relay will be operated by the marker for any call not requiring an office selection in the route. A two-wire office route can not be included in step-by-step calls. The four and five digit step-by-step calls will also require the SO relay to be operated for out-pulsing the required number of digits.

With the SO relay operated on any class by step-by-step,the OB- and OG- relays if operated will not be affective. The step-by-step class may have the SO relay and a combination of OG- relays operated. In this case, the OG- relays are used during out-pulsing of a sixth digit.

CLASS OF CALL

The class of call is indicated as follows:

Class of Call	Register Relays Operated OS(4-1)(3-1)
Full selector to panel	None
Full selector to crossbar	XB
PCI tandem 7 or 8 digit	TCI - CI

Class of Call	Register Relays Operated OS(4-1)(3-1)
PCI direct 4 or 5 digit	XB - TCI - CI
Overflow, vacant code or straight forward	OD - TCI
PCI tandem 3 digit	OD - TCI - CI
Step-by-step - 4 digit "A" loop	SSA - SO
Step-by-step - 4 digit "B" loop	SSB - SO
Step-by-step - 4 digit Bat. & Grd. pulsing	SSA - SSB - SO
Step-by-step - 5 digit "A" loop	SSA - IG5 - SO
Step-by-step - 5 digit "B" loop	SSB - IG5 - SO
Step-by-step - 5 digit Bat. & Grd. pulsing	SSA - SSB - IG5 - SO
Step-by-step - 6 digit "A" loop	SSA
Step-by-step - 6 digit "B" loop	SSB
Step-by-step - 6 digit Bat. & Grd. pulsing	SSA - SSB

COMPENSATING RESISTANCE

The compensating resistance used in the sender for office selections is indicated by the CR-4 relay.

Resistance in Sender for Office Selections	Relay Operated OS(4-1)
900 ohms	None
0 ohms	CR-4

The compensating resistance used for incoming trunk test and subsequent selections on crossbar and panel calls is indicated by the CR-1 and CR-2 relays. Compensating resistance is not required on step-by-step calls, OS(4-1).

Resistance in Sender for Incoming Selections or PCI	Relays Operated OS(4-1)
900 ohms	CR-1 CR-2
600 ohms	CR-2
300 ohms	CR-1
0 ohms	None

TRUNK TEST RELAY - OS(4-2)

The CR-5 relay is operated on all calls over trunk groups containing some trunks to non-repeating ground cutoff panel incoming selectors. It serves to substitue relay MTG for TG, to close a cable discharge circuit before final brush selection, and to close a path which insures operation of the O, BO and FO relays in case a very short reversed battery pulse is received in incoming advance.

FIFTH AND SIXTH DIGITS STEP-BY-STEP CALL

The step-by-step call may require that a fifth or a fifth and sixth digit be indicated by the marker. These digits are registered as follows. The fifth digit on the CR- relays and the sixth on the OG- relays shall be explained later.

STATION DELAY - OS(3-1)(4-1)

The SD relays indicate whether the called office is of such a kind as to require the sender to delay for the possible dialing of a fifth numerical digit or a party letter. The SD relay is left normal if the called office is a manual office having party lines, and is operated in all other cases. The SD-1 relay is left normal if the called office is a manual office having five digit numbers, and is operated in all other cases.

TW RELAY - OS(4-1)

The TW relay is operated when the call is routed through an office selector or through full selector tandem equipment, for extending the timing out period for stuck sender. It is also operated for operator class calls on which the trunk normally returns reversed battery during trunk test, serving to short-circuit the OF relay, OS(4-2).

RELEASE OF MARKER CONNECTOR

After the marker has operated the required selection register relays, it proceeds to select an idle trunk to a distant office selector or to the called office, and connect the originating trunk involved to the trunk by means of a trunk link, and office junctor, and an office link. After having selected the idle trunk, the marker connects ground to the DC lead through the connector to the sender, causing the following:

DC - OS(4-1)

The DC relay in the sender is operated by the marker in order to retain control of the sender after the marker connector is released. The DC relay operates through the marker connector from ground in the marker. The operating ground of the DC relay is extended thru the sender link crosspoints to the trunk when the DC relay operates. The trunk F relay operates and in turn extends the ground back to the marker, operating check relays. These check relays connect ground back over the lead from which they operated to lock the trunk F and sender DC relays in series. When this is accomplished,the marker connector can be released with the marker still controlling the sender. The DC relay in operating applies a soak to the STP relay to remove any residual magnetism due to the previous reverse battery and ground.

DRL - OS(4-1)

The marker causes the sender to release the marker connector by grounding the RL lead. The DRL relay in the sender operates and removes battery from the ST lead. The operation of the DRL relay causes the operation of either the S-3 or S-6 relay, OS(4-2). If the SO relay is normal, indicating that office selections are to be made, the S-3 relay operates at this time so that the sender will start its functions at office test. If the SO relay is operated, the S-6 relay operates so that the sender will start at trunk test. The sender waits for the marker to complete its functions and releases the sender circuit DC relay. Release of the DC relay permits the sender to advance to either office or trunk test depending on which of the two relays, S-3 or S-6 is operated. The shunt that prevented the operation of the S-3' or S-6' relay is removed when the DC relay releases. In this text it is assumed that offices selections are to be made.

FULL SELECTOR CLASSES OF CALL - OS(4-2)

There are two full selector classes, to panel and crossbar offices, respectively, this sender being arranged to control existing panel selectors in the same manner as a subscriber's sender controls them, and to transfer the number to crossbar terminating equipment using the same means. On a call to a crossbar office, the terminating sender replaces the functions of the panel incoming and final selectors in supplying the battery and ground required for trunk test, sending revertive ground pulses to satisfy the tandem sender, and providing the reversed battery signal after selections are completed. In sending the revertive ground pulses, the terminating sender records the called line number in terms of incoming and final selections, but transmits it to the terminating marker for selection of the line, in terms of the numerical digits originally dialed. On a full selector call to a panel office, no class relays are operated and on a call to crossbar the XB relay is operated. The XB relay operated in the latter case serves to extend the time that trunk test must be delayed and to eliminate the use of relay FO-1 on certain selections. On a call to panel, trunk test cannot be made until the thousands digit has been registered and an extra long time is required between certain selections. On a call to crossbar, trunk test cannot be made until the hundreds digit has been registered and extra long times between selections are not required. With these exceptions the two classes are treated exactly the same.

PROGRESS OF THE SELECTION SEQUENCE - OS(4-2)

The selection relays S-1 and S-1' to S-6 and S-6' and relays FS-1 and FS-2 are used to make the proper connections in the sender in a definite order as the sender progresses through its successive selections and trunk tests. On a full selector call to panel or crossbar these relays are operated as follows for the several stages:

Stage of Call	Relays Operated OS(4-2)
Office Test	S-3, S-3'
Office Brush Selection	S-4, S-4'
Office Group Selection	S-5, S-5'
Trunk Test	S-6, S-6'
Incoming Brush Selection	S-1, S-1', FS-1, FS-2
Incoming Group Selection	S-2, S-2', FS-1, FS-2
Final Brush Selection	S-3, S-3', FS-1, FS-2
Final Tens Selection	S-4, S-4', FS-1, FS-2
Final Units Selection	S-5, S-5', FS-1, FS-2
Incoming Advance	S-6, S-6', FS-1, FS-2

If office selections are skipped, the first three stages are omitted and trunk test becomes the first stage, with the S-6 and S-6' relays operated.

OFFICE TEST - OS(3-1)(4-2)(6)

If office selections are to be made the S-3 and S-3' relays are operated, as previously described. Operation of the S-3' relay causes sender circuit TG or MTG relay to operate. The TG or MTG relay is used for office test to determine that a normal trunk has been selected which is in condition for use. The FT and FR leads OS(4-2), are closed at this time through the sender link, trunk, trunk link frame and office link frame to the outgoing trunk to the office selector circuit. The battery and ground to operate the TG or MTG relay are furnished at the tip and ring, respectively, of the office circuit, the battery being applied through the winding of the office circuit L relay. The 14,500-ohm resistance in the circuit prevents the office circuit L relay from operating and permits the TG or MTG relay to operate only on 48-volt battery, thus preventing its operation if a trunk in talking position has been selected due to a trouble. The CR-5 relay, operated or left normal by the marker, determines which trunk guard relay is used. Either one may be used for office test, the requirement being based on the incoming trunk group through which the call is to be routed. If the incoming trunk group includes any trunks to non-repeating ground cutoff incoming selectors, the marker will have operated the CR-5 relay and the MTG relay will be used for office test and trunk test. Otherwise the CR-5 relay will be normal and the TG relay will be used. The path for operating the TG or MTG relay is traced through contacts of the CR-4 register relay operated or left normal by the marker. This affords a compensating resistance of 0 or 900 ohms. Any intermediate steps of compensating resistance must be wired at the office selector. The fundamental circuit for office brush and group selections also includes this resistance. This feature is provided to protect the fundamental relays against too heavy a current. With the S-6 relay normal at this period of the call the primary and tertiary windings of the OF relay are short-circuited in series and are not included in the fundamental circuit. Also in parallel, the S-3 relay operated is short-circuiting the primary winding of the OF relay.

FO

Operation of the FO relay advances the S- relay chain to operate the S-4 relay and upon its release the S-4' relay. Both of these relays operated allow the sender to make office brush selection.

OFFICE BRUSH SELECTION - OS(4-2)(6)

The battery and ground for operating the STP relay are furnished at the office circuit on the FT and FR leads, respectively, the office L relay being connected in the tip side and operating in series. The primary and tertiary windings of the OF relay, in parallel, are included in this path and in all other fundamental circuits for selections, but the relay does not operate as it is polarized and the current flow through the primary winding is not in its operate direction. The tertiary winding is non-inductive. Office brush selection is controlled by the OB selection register relays OS(4-1), operated by the marker as required. The path to operate the counting relay at which the count starts is traced from ground at the FS-3 relay normal, operated contacts of the STP relay, normal contacts FS-3 relay, operated contacts OF-2 relay, normal contact SS-1 relay, normal contacts 6' counting relay, normal contacts 1' relay, normal contacts FO-5 relay, operated contacts S-4' relay, normal contacts FS-2 relay, to the OB relays and over a numbered lead to the counting relay pair required, which corresponds in number to the required office brush. All leads on the print terminating in circles of like numerical designation are connected together. Operation of the office L relay advances the office circuit for making brush selection, ground pulses being impressed on the FT lead by the A commutator. These ground pulses alternately shunt the STP relay and permit it to reoperate, thus causing the prime counting relay associated with the relay previously operated and the lower numbered pairs to operate in order. The counting relays lock in series with their prime relays. The number of impulses received is equal to the number of counting relay pairs included in the selection, and is always one greater than the number of the counting relay at which the count starts. When the last ground pulse is received, shunting the STP relay, the BO and FO relays operate in parallel. The BO relay opens the fundamental circuit, preventing reoperation of the STP relay.

FO - OS(4-2)

Operation and release of the FO relay causes the S- relay chain to be advanced to the S-5 and S-5' relays for office group selections.

SLOW RELEASE FO-1 RELAY

The slow release FO-1 relay is used to increase the open period between fundamental closures by approximately .065 second, making the total open period, from operation of the BO relay to operation of the FO-3 relay, approximately .130 second. This feature is necessary only in certain selections involving panel selectors, and not in any case in connection with crossbar terminating equipment. This long delay is required to permit a panel selector to advance in any No. 0 selection which starts with the selector commutator already closed. This condition is obtained in final frames with a combination of No. 4 brush and No. 0 tens. In these cases, the B commutator is left closed when brush selection is completed. Closure of the fundamental for tens selection operates the L and STP relays and when the L relay contact closes the STP relay is immediately shunted, satisfying the sender. After that, the selector circuit has to advance its switch and raise its brush rod, breaking the commutator before it can advance for the next selection. A similar condition is encountered in final units selection on a call in which the units digit is zero. In order to allow sufficient time for the selector to advance before the sender again closes the fundamental and thus prevent out of step conditions due to the above, the slow release FO-1 relay is employed on panel calls after final tens, and final units selections. The long delay is not needed after office brush selection, but is used in this case because the S-5 relay also operates after final tens selection where the delay is necessary.

OFFICE GROUP SELECTION - OS(5-1)(5-2)

The STP relay operates in series with the office circuit L relay, the battery and ground being furnished at the office circuit, as described for office brush selection. Office group selection is controlled by the OG selection register relays operated by the marker as required. The path to operate the counting relay at which the count starts is as described for office brush selection, except that the OG relays are used due to the S-5' relay being operated. Operation of the office L relay advances the office circuit for making group selection, ground pulses being impressed on the FT lead by the B commutator. These ground pulses alternately shunt the STP relay and permit it to reoperate, thus causing the counting relays to operate in order as previously described, OS(5-1). In the office selector frame there are ten groups in a bank, OS(5-1). If group No. 5 or over is to be selected, the counting relays are split by the OB-5 relay operated. In this case the count starts at the relay pair numbered 5 less than the group desired, except for No. 5 group, the count for which starts at the No. 6 relays, using No. 0 lead. The counting relays, when split, are connected to operate in the following order: 4, 3, 2, 1, 6, 5, 4, 3, 2 and 0. To accomplish this, the RC relay releases when the No. 5 relay operates and the No. 4, 3 and 2 pairs, operated on the first cycle, release when the No. 6 relay operates so that they may be used a second time. Also, the OG-5 relay operated connects No. 1 pair to No. 6 pair instead of to No. 0 relays, to give the above sequence and the RC relay normal on the second cycle connects No. 2 pair to the No. 0 relays. When the last ground pulse is received, shunting the STP relay, the BO and FO relays operate in parallel. The BO relay opens the fundamental circuit, preventing reoperation of the STP relay. In order for the FO-1 relay to release, the thousands digit must have been dialed if the call is to a panel office, and both the thousands and hundreds digits must have been dialed if the call is to a crossbar office. In either case the TH hold magnet normal provides a holding path for the relay, and with the XB relay operated (call to crossbar office) the H hold magnet normal also provides a path. This feature is used to delay trunk test and incoming brush selection until sufficient digits have been dialed.

FO

The operation and release of the FO relay caused the advance of the S-relay chain to the S-6 and S-6' for trunk test.

SKIP OFFICE - OS(4-2)

If no office selector is included in the routing, the marker operates the SO relay. In this case operation and release of the DC relay would have operated the S-6 and S-6' relays, the operations given under office test and office brush and group selections are omitted, and the sender starts at trunk test, described below, upon operation of the S-6' relay.

TRUNK TEST - OS(4-2)(3-1)(6)

The TG or MTG relay is used for trunk test to determine that a normal trunk has been selected which is in condition for use. The FT and FR leads are closed at this time through the equipment of the calling office, and through a distant office selector, if used, to the outgoing trunk to the called office. The battery and ground to operate the TG or MTG relay are furnished at the tip and ring, respectively, of a panel incoming selector or a crossbar incoming trunk in the called office. The 14,500-ohm resistance in the circuit prevents the advance of the terminating circuit until such time as the sender is ready for selections, and it permits the TG or MTG relay to operate only on 48-volt battery, thus preventing its operation if a trunk in talking position has been selected due to a trouble. As previously described, the CR-5 relay, operated or left normal by the marker determines which trunk guard relay is used. If the incoming trunk group includes any trunks to non-repeating ground cutoff incoming selectors, the marker will have operated the CR-5 relay and the MTG relay will be used. Otherwise the CR-5 relay will be normal and the TG relay will be used. The path for operating the TG or MTG relay is traced through contacts of the CR-1 and CR-2 selection register relays, operated or left normal by the marker, and through sufficient resistance to increase the trunk resistance to a minimum of 900 ohms. The fundamental circuits for incoming and final selections and incoming advance also include this resistance.

FO

The operation and release of the FO relay advances the S- relay chain to the S-1 and S-1' for incoming brush selection.

INCOMING BRUSH SELECTION - OS(4-2)

As previously described on full selector calls to panel or crossbar, the sender translates the called line number into terms of incoming and final selections, and is satisfied for these selections by revertive ground pulses from the incoming and final selectors or from a crossbar terminating sender. The selections described below apply to both full selector classes. The battery and ground to operate the STP relay are furnished over the FT and FR leads from the tip and ring, respectively, of a panel incoming selector or a crossbar terminating sender. Incoming brush selection is controlled by the TH vertical on the crossbar switch, the operated contacts on this vertical closing a path to a particular counting relay, depending upon the thousands digit dialed, OS(5-1)(5-2). The path to operate the counting relay at which the count starts is similar to the path given for office brush selection, except that the S-1' relay operated closes it through the thousands vertical. The following formulas may be used to determine at what counting relay the count starts for incoming and final selection for any number.

$$\text{Incoming Brush} = \frac{\text{Called Number}}{2000}$$

The called number is divided by 2000 because an incoming brush has access to 2000 lines. The remainder is disregarded for incoming brush but is used for other selections.

$$\text{Incoming Group} = \frac{\text{Remainder of Incoming Brush}}{500}$$

The divisor of 500 is used because an incoming group has access to 500 lines. The remainder of this operation is disregarded for incoming group but is used for other selections.

$$\text{Final Brush} = \frac{\text{Remainder of Incoming Group}}{100}$$

The divisor of 100 is used because a final brush has access to 100 lines.

Final Tens = Tens Digit
Final Units = Units Digit

When the STP relay operates, due to closure of the fundamental circuit, the terminating equipment also advances and returns ground pulses to the sender over the FT lead. These ground pulses cause the STP relay to release and reoperate and the counting relays to operate in order as before. For all incoming and final selections operated contacts of the SR-1 relay are included in the path from the operated contact of the No. 1' counting relay to the next pair to operate which is always zero for incoming selections and final brush selection and may be either zero of 6 for final tens and final units, as described later. The SR-1 relay contacts are included in this path so that, in case of a premature disconnection, as described later, release of the SR-1 relay may cause an incoming or final telltale. The BO relay opens the fundamental circuit, OS(4-2).

FO

The operation and release of the FO relay advances the S- relay chain to the S-2 and S-2' relays for incoming group selections, OS(4-2).

FO-1 - OS(4-2)

The FO-1 relay releases if the hundreds digit has been dialed on the panel type call. Otherwise incoming group selection is delayed by a path which holds the FO-1 relay through the normal contacts of the H hold magnet. On a crossbar call there will not be any delay as the registration of the hundreds digit was required in order to make trunk test, OS(8).

INCOMING GROUP SELECTION - OS(4-2)

The battery and ground to operate the STP relay are furnished by the incoming selector or crossbar terminating sender as before. Incoming group selection is controlled by the TH and H verticals of the crossbar switch, the counting relay path being closed through them by the S-2' relay operated, OS(5-1)(5-2). The terminating equipment advances and returns ground pulses causing the STP relay and the counting relays to function as before. The BO relay opens the fundamental circuit.

FO - OS(4-2)

The operation and release of the FO relay advances the S- relay chain to the S-3 and S-3' relay for final brush selection.

FO-3 RELEASE - OS(4-2)

As previously described the CR-5 relay is operated if the trunk group includes any trunks to non-repeating ground cutoff panel incoming selectors. If it is operated, the release of the FO-3 relay connects 25,500-ohms resistance across the FT and FR leads to discharge the trunk cable. This is done to avoid danger of a false pulse through the STP relay due to connection of the final circuit L relay to the fundamental. The 25,500-ohm resistance bridge, if connected as above, is removed when the FO-3 relay operates.

FINAL BRUSH SELECTION - OS(4-2)

The battery and ground to operate the STP relay are supplied to the FT and FR leads by the terminating selectors or sender as before. Final brush selection is controlled by the H vertical of the crossbar switch, the counting relay path being closed through it by the S-3' relay operated, OS(5-1)(5-2). The terminating equipment advances and returns ground pulses, causing the STP relay and the counting relays to function as before. The BO relay opens the fundamental circuit.

FO - OS(4-2)

Operation and release of the FO relay advances the S- relay chain to the S-4 and S-4' relays for final tens selection.

FS-3 - OS(4-2)

The FS-3 relay reverses the direction of current through the contacts of the STP relay to give longer life to these contacts.

FO-2 - OS(4-2)

The FO-2 relay releases only if the tens digit has been dialed on crossbar to crossbar calls. On calls from crossbar to panel, the FO-1 relay releases if the tens digit has been dialed. Otherwise, tens selection is delayed by a path which holds the FO-2 or FO-1 relay through contacts of the T hold magnet normal.

FINAL TEN SELECTION - OS(4-2)

The battery and ground to operate the STP relay are supplied by the terminating selectors of sender as before. Final tens selection is controlled by the T vertical of the crossbar switch, the counting relay path being closed through it by the S-4' relay operated, OS(5-1)(5-2). The terminating equipment advances and returns ground pulses, causing the STP relay and the counting relays to function as before. OS(5-1)(5-2). The counting relays are split for this selection as described for office group selection but controlled by the T vertical, if the tens digit dialed is 5 to 9. In this case, the count starts at the relay pair numbered 5 less than the count desired, except for No. 5, the count for which starts at the No. 6 relays, using No. 0 lead. The counting relays, when split, are connected to operate in the following order: 4, 3, 2, 1, 6, 5, 4, 3, 2 and 0. As previously described, the RC relay releases when the No. 5 relay operates and the No. 4, 3 and 2 pairs operated on the first cycle, release when the No. 6 relay operates so that they may be used a second time. A second row of contacts on the T vertical is used to connect the operated contact of the No. 1' relay (through the switching relays and the SR-1 relay operated) either to No. 0 relay or No. 6 pair as required. The BO relay opens the fundamental circuit.

FO

Operation and release of the FO relay advances the S- relay chain to the S-5 and S-5' relays for final units selection.

FO-1 - OS(4-2)(8)

The FO-1 relay, if used, or the FO-2 relay, if the FO-1 is not used, releases only if the units digit has been dialed. Otherwise, units selection is delayed by a path which holds the FO-1 or FO-2 relay through contacts of the STL relay normal.

FINAL UNITS SELECTION - OS(4-2)

The battery and ground to operate the STP relay are supplied by the terminating selectors or sender as before. Final units selection is controlled by the U vertical of the crossbar switch, the counting relay path being closed through it by the S-5' relay operated, OS(5-1)(5-2). The terminating equipment advances and returns ground pulses, causing the STP relay and the counting relays to function as before. The counting relays may be split for this selection as described for final tens selection, but controlled by the U vertical. A second row of contacts on this vertical is used to connect the operated contact of the No. 1' relay (through the switching relays and the SR-1 relay operated) either to No. 0 relay or No. 6 pair as required. The BO relay opens the fundamental circuit.

FO

Operation and release of the FO relay causes the S- relay chain to advance to the S-6 and S-6' for incoming advance.

INCOMING ADVANCE - OS(4-2)

The sender is now in a position to receive battery on the FR lead and ground on the FT lead from the incoming circuit or terminating sender as a signal that all selections have been completed. Closure of this reversed battery advances a distant office selector if included in the routing from selection beyond position to talking position. The incoming selector or terminating sender, after having connected the reversed battery, advances further and removes it. Non-repeating ground cutoff panel incomings give so short a reversed battery pulse that the STP relay may not stay operated long enough after IA operates to operate the O relay, so the above described method of operating BO and FO at the end of the pulse may fail. To insure the operation of BO and FO, the IA relay closes a supplementary path through operated contacts of the CR-5 relay to operate O, BO and FO simultaneously when the STP relay releases, in case the O relay was not operated before, OS(5-1)(5-2). The supplementary path would cause BO and FO to operate too soon in case the IA relay should close it before the STP relay operates. This is a possibility on long trunks which cause the STP relay to lag in operation behind the OF relay, OS(4-2). It would cause the sender to proceed without insuring the advance of the incoming and checking that it does advance. To prevent this, the supplementary path is carried through the CR-5 relay operated, as described above, and is, therefore, ineffective on trunks not requiring it. Operation of the BO relay at this time breaks the bridge across the fundamental in the sender to prevent its giving a premature trunk closure.

DISCONNECTION - OS(4-2)(3-1)(9)

The AV relay in operating starts the release of the sender hold magnets and connects ground to the D lead, OS(4-1). The D lead ground operates the D and D-1 relays in the trunk circuit to advance the trunk to trunk closure. Operation of the D-1 relay connects ground to the DC lead, OS(4-1), back to the sender. This ground causes the sender to open the CO lead releasing the trunk T relay. The D relay in trunk operates due to released T relay and disconnects ground from the DC lead. Trunk circuit A relay operates on release of the T relay placing connection under control of "A" switchboard. Sender circuit CK-2 relay opens the T & R leads prior to their being opened by the sender link crosspoints to protect these crosspoint contacts, OS(4-1). Release of the ON-2 due to the operation of the AV-4 releases the sender link hold magnets by opening the S lead, OS(2-1). The various operated relays in the sender, release as shown in the circuit operation diagram, OS(2-2, SC-1).

STEP-BY-STEP CALL - OS(4-3, SC-5)

Calls to step-by-step offices may be routed though the same channels as panel, crossbar or P.C.I. calls, with the exception of the two-wire routing. The step-by-step call may route through one or two intermediate step-by-step offices. When it is desired to route the call through intermediate step-by-step offices the marker will supply the necessary information to the sender. This information will be in the form of fifth and sixth digits. This creates three classes of step-by-step calls, namely, four, five and six digit classes. These classes are registered in the sender by means of the SO and IG5 relays operated or released, OS(4-1). The extra one or two digits are registered on the CR- and OG- relays, OS(4-1). The fifth digit is registered on the CR- relays and the sixth on the OG- relays. It can be seen that the use of the OG- and CR- relays for this purpose precludes the use of any two-wire routing. These extra digits are known as directing digits and guide the intermediate step-by-step equipment. It is also possible to have any one of three types of pulsing loops between the dial pulse sender and the step-by-step equipment. The type of loop is indicated to the sender by combinations of the SSA and SSB relays. Loop "A" has the 300-ohm AR resistance included in the fundamental circuit between digits. Loop "B" has the 1481-ohm AE resistance in the fundamental circuit at all times. The battery and ground pulsing has 210-ohm battery on the FR lead and 210-ohm ground on the FT lead, OS(4-2). Numbers over ten thousand and party letters are not used on the step-by-step classes of calls. Party lines are up on a straight numerical basis. The out pulses from the dial pulsing sender are generated by the condenser timed PGS relay, OS(4-2)(7), and are counted on the counting relays. The counting relay connections have to be shifted on the step-by-step class of call because the pulses sent must correspond to the digit dialed. Step-by-step equipment follows the dial pulses on a direct basis for its selections. It can be seen that sending one pulse for one dialed will require the counting relays to start at zero counting relay. A zero dialed will require ten pulses to be sent instead of one as a panel or crossbar. The operated SS1 to 7 relays make the required changes, OS(5-1)(5-2). The polarized PLS relay, OS(4-2)(5), will short-circuit the FT and FR leads when on its front contacts for loop "A" and "B." When battery and ground pulsing is required, the operated SAB relay, OS(7), causes the OPA relay to be connected to the contacts of the PLS relay. The OPA relay follows the operations of the PLS relay and provides the required battery and ground. The CK relay counts down the counting relays from its back contacts at the open period of the pulse, OS(4-2). The PLS and CK relays follow the PGS relay. The operation of the PGS relay will be discussed in detail later, OS(4-2)(7).

Step-by-Step Class Indication Relays - OS(4-1)

Class	Relays
Four digit loop "A"	SSA - SO
Four digit loop "B"	SSB - SO
Four digit bat. & grd. loop	SSA - SSB - SO
Five digit loop "A"	SSA - SO - IG5

Class	Relays
Five digit loop "B"	SSB - SO - IG5
Five digit bat. & grd. loop	SSA - SSB - SO - IG5
Six digit loop "A"	SSA
Six digit loop "B"	SSB
Six digit bat. & grd. loop	SSA - SSB

Step-by-Step Fifth Digit Register Relays

Digit	Leads Grounded	Relays Operated
1	None	None
2	CR1	CR1
3	CR2	CR2
4	CR1 - CR2	CR1 - CR2
5	CR4	CR4
6	CR5	CR5
7	CR5 - CR1	CR5 - CR1
8	CR5 - CR2	CR5 - CR2
9	CR5 - CR2 - CR1	CR5 - CR2 - CR1
0	CR5 - CR4	CR5 - CR4

Step-by-Step Sixth Digit Register Relays - OS(4-1)

Digit	Leads Grounded	Relays Operated
1	None	None
2	OG1	OG1
3	OG2	OG2
4	OG1 - OG2	OG1 - OG2
5	OG4	OG4
6	OG5	OG5
7	OG5 - OG1	OG5 - OG1
8	OG5 - OG2	OG5 - OG2
9	OG5 - OG2 - OG1	OG5 - OG2 - OG1
0	OG5 - OG4	OG5 - OG4

Six Digit Call

This type of call proceeds as any other type until the tandem marker returns the required information to the sender. The marker will operate the SSA or SSB or both. It is assumed in this text that only the SSA is operated for the "A" loop type. The OG- and CR- relays will be operated as required. The compensating resistance setup subsequent to the operation of the CR- relays is not effective because it is removed from the fundamental circuit by the operation of the SS3 relay. On a six digit call the SQ and IG5 relays are not operated. At this point,the following relays are operated: FOO or F10, CS-, ON1, ON2, ON3, AV3, OF2, SR, SR1, L, L1, L2, RA1, AL1, AL2, CL, CK4, RV1, RV2, RV3, TG3, SS, SS1 to 7, DST, DC, SD, SD1 and the previously mentioned class (SO, IG5) and register (CR- and OG-) relays. The F, A, B and C hold magnets are operated. The TH, H, T and U hold magnets depending on how far dialing has progressed. The UL1, UL2, OS(2-1), STB, STB' and STL, OS(3-1), relays will operate when the units digit is dialed. The SS relay operated, OS(4-2), when the SSA or SSB operated and in turn operated the SS1 to 7 relays, OS(5-1)(5-2). The FO8 relay operates when the SS1 operates.

TRUNK TEST

When the marker advances into the marker stage, it will operate the sender DRL relay which with the DC relay operated will cause the operation of the TTD relay. The DC relay has been previously operated through the marker connector and locked through the sender link. There is no delay of trunk test as in a six digit call the sixth and fifth digits may be out-pulsed before any additional dialing is required, OS(4-1).

S6

Operates when the TTD operates. All step-by-step classes make trunk test with the S6 and S6' relays. Variations for four and five digit calls will be given later, OS(4-2).

DC - OS(4-1)

The DC relay releases when the marker has completed its functions. This causes the release of the slow release TTD relay. The release of the DC relay removed the soak circuit of the STP relay. On a step-by-step call this circuit has no function, as the STP relay is not used, but as it does not cause any reaction it is not eliminated.

TTD - OS(4-1)

This relay is made slow release to give any step-by-step equipment which was selected in the process of returning to normal a chance to restore before trunk test is made. The TTD relay in releasing removes the shunting ground from the winding of the S6' relay allowing it to operate.

TG - OS(4-2)

The TG relay is always used for trunk test on step-by-step class of calls. The MTG path is cancelled by the operation of the SS relay if it should be cut in by the operation of the CR-5 relay. The operating path of the TG relay is traced as follows: battery on FT lead, normal FTT relay, normal AV2 relay, normal AV relay, operated FO3 relay, normal FO2 relay, operated S6 relay, normal TCI relay, normal FS1 relay, TG relay winding, 7000-ohm SS resistance, operated SS relay, 14,500-ohm AF resistance, normal TCI relay, operated S6' relay, operated or normal CR1 and CR2 relays, normal AV relay, normal FTT relay to FR lead ground. The OF relay primary winding is shunted out of the TG operating path as it is not desirable to recognize a reversed trunk at this time. The 21,500-ohm resistance in the trunk test circuit prevents the operation of the line relay in the repeater or selector circuit at the distant office.

TG1

The TG1 relay is made slow release to hold over any momentary release of the TG relay.

S7 - OS(4-2)

The S7 relay operates from the FO relay operated in conjunction with the SO relay normal. It has been previously stated that the SO and IG5 relays are normal for this class of call. The S7 and S7' relays are operated for the purpose of having two directing digits out-pulsed before the directory number on a step-by-step six digit call.

FO2 - OS(4-2)

Opens the fundamental circuit releasing the TG relay. The operated FO2 relay also releases the RC and FO3 relays. The FO3 relay releasing causes the FO8 relay to release which opens the locking circuit of the O, BO and FO counting relays. These counting relays will hold until the TG2 relay releases.

FO

The release of the FO counting relay, after the TG2 relay releases, removes the shunting ground from the S7' relay allowing its operation.

FO2

Release of the FO2 causes the sender to operate the RC, FO3 and FO8 relays. The FO8 in operating causes the SSP relay to operate to start out-pulsing.

GENERATION OF PULSES - OS(7)(4-2)

The step-by-step out-pulsing circuit consists of the following relays: SSP, PGS, CK, PLS and when the battery and ground pulsing is required the OPA and OPC relays. The PGS relay does the actual pulsing controlling the CK and PLS relays. The PLS relay applies the pulses to the FT and FR leads directly or by means of the auxiliary OPA relay when battery and ground pulsing is required. The CK relay counts down the counting relays. Both the PLS and CK relays follow the operation of the PGS relay. The SSP relay starts or stops the pulsing on its operation and release by removing or applying the shunting ground to the 300-ohm AM battery. The PGS relay is a condenser timed non-biased relay. The timing condenser is the PGS condenser which is in series with the secondary winding of the PGS relay. Removal of the shunting ground from the 300-ohm AM battery causes both windings of the PGS relay to be energized. The relay, however, cannot operate immediately because the secondary winding is momentarily stronger than the primary. This is due to the current flow while the PGS condenser is charging. As the condenser approaches its full charge, the current through the secondary winding decreases. When a point is reached at which time the current flow in the secondary winding cannot create a field strong enough to oppose the primary field, the relay will operate and close its front contact. The circuit through the secondary winding is traced as follows: 300-ohm AM battery, secondary winding of PGS relay, PGS condenser, from the other side of the condenser to ground at the operated SS relay. The circuit through the primary winding is traced as follows for the "A" or "B" loop: 300-ohm AM battery, primary winding of PGS relay, winding of CK relay, winding of PLS relay, normal SAB relay, AN 410-ohm battery in parallel with 490-ohm AD and 50-ohm AC resistances, to ground at the operated SS relay. When the battery and ground pulsing is required, the SAB relay will be operated and substitute the 350-ohm AK battery and resistance network for the AN battery. It will also substitute the AG resistance network for the AC resistance. This will slow up the PGS relay and consequently, slow up the pulsing to the step-by-step office. When the PGS relay front contact closes, the 300-ohm AM battery is shunted. This allows the AN or AK battery to take effect because those batteries are not shunted by direct ground. The AN or AK batteries energize the primary winding to operate the PGS relay on its back contact. It cannot operate immediately because closure of the front contact has provided a path for the discharge of the PGS condenser. The current, created by the discharging PGS condenser, is flowing through the secondary winding in the direction that will hold the PGS relay on its front contact. As the condenser approaches its fully discharged condition, the flow of current in the secondary winding decreases to the point when the field is too weak to oppose the primary winding and the relay operates to its back contact. On the back contact, the procedure is repeated as stated. This continues until the SSP relay is released at the end of the digit, shunting the 300-ohm AM battery and holding the PGS relay on its back contact. It can be seen that the PGS relay is held on its back contact while the PGS condenser is charging and on its front contact while the condenser is discharging. The CK and PLS relays are operated to the front contacts while the PGS relay is on its front contacts and while the SSP relay is normal. The PLS relay, when the "A" or "B" pulsing loops are required, short-circuits the FT and FR leads for the pulse on its operation to its front contact. When the battery and ground pulsing is required, the PLS contacts are disconnected from the FT and FR leads and connected to the OPA relay winding and ground. The OPC is slow release to hold operated between pulses. Between digits the OPC relay will be released, placing the 250-ohm AB resistance across the FT and FR leads. Prior to sending the first pulse, a complete pulse cycle is made with the FT and FR leads short-circuited. This is to allow time for soaking the repeater relays in the outgoing trunk. The fundamental circuit during pulsing is traced as follows: FT lead, normal FTT relay, operated FS4 relay, OF relay primary and tertiary windings in parallel, operated FS1 relay, operated SS3 relay, normal LR1 relay, normal SAB relay, PLS relay, normal SAB relay. The variations for loops "A" and "B" occur at this point. Loop "A" normal SSB relay, operated SSP relay, normal SSB relay, normal SAB relay to FR lead. Loop "B" operated SSB relay, 1481-ohm AE resistance, operated SSB relay to FR lead. Variations for battery and ground pulsing occur after normal LR1 relay, operated SAB relay, OPA relay, operated SSA relay, operated OPC relay to 210-ohm ground. FR lead operated SAB relay, operated OPA relay, operated SSA relay, operated OPC relay to 210-ohm battery.

SSP

When the SSP relay is operated, it allows the PGS relay to start pulsing by removing the shunting ground from the 300-ohm AM battery. It also short-circuits the 300-ohm AR resistance in the fundamental circuit for the "A" loop. The SSP relay operated causes the CK and PLS relays to be operated down.

CK AND PLS (Back Contacts)

The CK relay causes the F06 relay to operate and lock. The PLS relay has no effect at this time.

CK AND PLS (Front Contacts)

The CK and PLS are operated on their front contacts when the PGS relay closes its front contact after the condenser charging interval. The CK relay causes the operation of the F07 relay which locks. PLS is now in control of the short-circuit of the FT and FR leads.

FO7

Closes back contact of CK relay to the counting relays. Removes the short-circuit from the FT and FR leads to permit the PLS relay closures and opens to be effective. At this point, the pulses will be effective to the step-by-step equipment and the counting relays will be counted down.

COUNTING RELAYS - OS(5-1)

On the assumption that the call involved is a six digit call, the counting relays for the sixth digit are controlled by combinations of the OG- register relays. The counting relays operate when the CK relay is on its back contact. The prime counting relays operate when the CK relay is on its front contact. As it has been previously stated,the number of pulses sent will correspond to the digit dialed or in the case of the five or six digit call, setup by the marker on the CR- and OG- register relays. If the required digit is higher than 5,it is necessary to split the counting relays. In this case,the 6 counting relay will operate before the zero. In operating the 6 counting relay,the 2 to 4' counting relays release. The 1 counting relay remains locked up. The zero counting relay operates after the 2 and 2' counting relays. The FO operates when the CK operates after the last pulse of the digit. The BO operating in parallel with the FO relay has no function on step-by-step calls.

FO

The FO in operating,releases the SSP relay and operates the FO4 relay. The FO5 is shunted and cannot operate at this time.

SSP - OS(7)

The SSP relay released,holds the CK and PLS relays on their front contacts and will cause the PGS to remain on its back contact once it is operated down. The PLS relay is held to maintain the short-circuit of the fundamental for "A" and "B" loops and to hold the OPA relay operated for the battery and ground loop.

FO4

With the FO4 relay operated and the FO5 relay normal, the FO2 relay operates.

FO

The O, BO and FO counting relays released due to the FO8 relay release. The FO counting relay in releasing,removes the shunt preventing the operation of the FO5 relay which now operates.

FO5

The FO5 relay supplements the PLS relay contacts,holding the short-circuit on the fundamental or holding the OPA operated. This is necessary to protect the circuit during interdigital timing which will be covered in detail later. The FO5 relay cuts in the 4 counting relay for the timing. The FO5 relay operated,releases the FO2 relay.

FO2

The FO2 relay released, starts the chain of operations terminating in the operation of the SSP relay. Operation of the SSP starts the PGS relay pulsing for interdigital timing.

INTERDIGITAL TIMING

On the step-by-step class of call, it is necessary to have a definite time interval introduced between out-pulsing of each digit. If this were not done, it would be possible for the sender to get ahead of the step-by-step equipment. Without this timing, the sender could advance to the next digit in just the time it takes for the relays to operate. The step-by-step office has to hunt after each digit and then set itself for the next group of pulses. The timing cycle extends from the last pulse of one digit to the first pulse of the next digit. The FO5 relay when it operates short-circuits the fundamental or holds the OPA relay operated. The OPA operated holds the 250-ohm AB resistance across the FT and FR leads. The FO5 relay also connects the pulsing circuit to the number 4 counting relay. When the SSP relay operates, the pulsing circuit functions as for a digit in selections, counting down the four sets of counting relays as a time interval. These pulses are not transmitted to the step-by-step equipment because the FO5 relay has short-circuited the FT and FR leads. When the FO counting relay operates, the SS relay is released to stop the pulsing. The CK and PLS relays are held on their front contacts. The PGS relay will be held on its back contact when it operates down. Closure of the make contacts of the FO counting relay starts a series of operations to set the sender for out-pulsing the next digit. The interdigital timing interval is approximately .6 seconds.

S1

The S1 and S1' relays are operated to shift the counting relays to the CR- relays for pulsing the fifth digit of the assumed six digit call.

SSP

When the SSP relay reoperates, the pulsing circuit will start to pulse the fifth digit in the same manner that the sixth digit was out-pulsed. After the digit is completed, an interdigital timing interval takes place once more. Each time the FO4 relay is released, the S- relay chain will be advanced to the next S- relay. Release of the FO5 will operate the next S' - relay. There is a delay introduced to stop out-pulsing if the thousands digit is not dialed by the time the sender is ready to out-pulse that digit. This is done by holding the FO2 relay operated to the thousands hold magnet normal. All operations from the release of the SSP after the interdigital timing until the release of the FO2 may take place. The FO2 relay waits until thousands are dialed before releasing, OS(8). The same procedure will take place if the hundreds digit is not dialed by the time the sender is ready to out-pulse that digit. The FO2 relay will be held operated by the hundreds hold magnet being normal. When the S4 relay operates for the out-pulsing of the tens digit, the WU relay operates. The FO2 relay will now be held operated through the WU relay operated until the STL relay operates after the units have been dialed. The tens cannot be out-pulsed until the units are registered, OS(4-2) (7). The operation of the SSP relay for pulsing the units digit causes the

SDC relay to operate and lock. When the FO counting relay operates at the last pulse of the units digit, the AV relay operates due to the SDC being operated, OS(9). Operation of the AV relay causes the sender to advance and release as for the full mechanical panel or crossbar call.

STEP-BY-STEP FIVE DIGIT CALL

This call proceeds as the six digit call except for the following variations: The marker on decoding the call will not operate any of the OG- relays. The marker will cause the operation of the SO and IG5 relays. Out-pulsing will start at the S1 and S1' relays omitting the S7 and S7' relays, thus allowing only one directing digit to be out-pulsed. Trunk test will not be delayed. Delay of the pulsing of the thousands, hundreds and tens digits, if required, is accomplished as for the six digit call.

STEP-BY-STEP FOUR DIGIT CALL

On this type of call, trunk test cannot take place until the thousands digit is registered in the sender. Out-pulsing of the thousands digit takes place immediately following trunk test. The FO-1 relay will operate for this call when the S6 relay operates with the SO operated and the IG-5 normal. This keeps the fundamental open, delaying trunk test until such time that the thousands digit is dialed. The marker will not operate any OG- or CR- relays. Out-pulsing will start at the S2 and S2' relays omitting the S7, S7' and S1 and S1' relays. No directing digits are required for this type of call. Any delay required in pulsing the hundreds and tens digits will be accomplished as for the other two classes.

DISCONNECTION

The step-by-step class of call functions in the same manner as the panel or crossbar call on disconnection. When the FO relay operates on the last closure of the units digit, the AV relay is operated due to the SDC relay being operated. The AV relay operates the AV1 which starts the disconnection by releasing the F hold magnet, OS(2-1).

PANEL CALL INDICATOR - OS(3-1, 3-2, 3-3), SC-4

PANEL CALL INDICATOR EQUIPMENT

Panel call indicator equipment is provided in manual central offices for completing calls from dial offices. Calls routed directly from a tandem crossbar office to a terminating manual office are called direct P.C.I. calls. The action of the tandem crossbar circuits for a P.C.I. call is similar to a full selector call up to the connection to the outgoing trunk to the called office, except that a stations digit may be dialed. The trunk is wired to a call indicator trunk circuit at a "B" switchboard position, arranged with a cord and plug for manual connection to the called line jack. An associated control circuit is used to display the called number by means of lamp signals, which are set up by pulses from the calling sender. In a call of this type, pulses for five digits are sent. These are a party letter or the ten-thousands digit of a five digit number, and the thousands, hundreds, tens and units digits. If the called number is a four digit number, the sender transmits pulses for zero in the party letter or ten-thousands position, although no such digit is dialed. The maximum number of lines in a manual office is 10,500, and the ten-thousands digit is consequently 0 or 1. Tandem P.C.I. calls are routed from a tandem crossbar office through a mechanical tandem office, used as a distributing point, to the called office. On these calls P.C.I. pulses are used to transmit both the office code and the called line number to the tandem sender, so that it can control the selection of a trunk and the completion of the call.

PANEL CALL INDICATOR CODE - OS(3-1)

P.C.I. pulses used in transmitting a number, consist of light negative, heavy negative, and positive pulses. A light negative pulse is a closure of battery through high resistance (6500 ohms) on the ring of the trunk and ground on the tip. A heavy negative pulse is a closure of battery through low resistance (6500 ohms and 115 ohms in parallel) on the ring and ground on the tip. A positive pulse is a closure of battery through high resistance (6500 ohms) on the tip and ground on the ring. After transmission of the pulses for the number, a final heavy positive pulse is sent, consisting of battery through low resistance (6500 ohms and 115 ohms in parallel) on the tip and ground on the ring, its purpose being to advance a distant office selector, if used, and to complete the display at the P.C.I. position or advance a tandem sender. These pulses are produced by the operation and release of a condenser timed relay and its auxiliary relays, four pulse positions being provided for each digit. The operated crosspoint contacts on the dial register determine the combination of pulses sent for a particular digit dialed. The crossbar switch verticals are connected in sequence for transmission of the digits by means of the P.C.I. progress relays A and A' to STB and STB', as required. Negative pulses, either light or heavy, are always closed in the second and fourth pulse positions for a digit. Positive pulses may be closed in the first and third positions, or these positions may be open. Two negative pulses are sent for each digit to advance the call indicator or tandem sender circuit so that the successive digits will be routed to the proper groups of register relays. Light negative pulses perform this function only; heavy negative pulses, in addition, cause register relays to operate. Positive pulses also cause the operation of register relays. If no party letter or ten-thousands digit is dialed, pulses for a zero are sent in the party letter or ten-thousands position, so that the following digits will register correctly. The following table shows the pulse code for the various digits. The code for thousands is different from the code for hundreds, tens and units in order to transmit the number in terms of incoming and final selections, so that a tandem sender, in turn controlling dial terminating equipment, does not have to perform the function of numerical translation.

PULSE CODE

Thousands	Tandem and Numerical Hundreds, Tens & Units	Ten-Thousands and Stations	Pulse Closures			
			1	2	3	4
0	0	0		Lt.Neg.		Lt.Neg.
2	1	1	Pos.	" "		" "
4	2	W (9)		Hv.Neg.		" "
6	3	R (7)	Pos.	" "		" "
8	4	J (5)		Lt.Neg.	Pos.	" "
1	5	M (6)		" "		Hv.Neg.
3	6		Pos.	" "		" "
5	7			Hv.Neg.		" "
7	8		Pos.	" "		" "
9	9			Lt.Neg.	Pos.	" "

DIRECT P.C.I. CALL

TO OFFICES WITH FOUR DIGIT NUMBER ONLY

The action of the sender circuit on this type of call is as described for a full selector call up to trunk test, office selections being made or skipped as desired. The exceptions are as follows, the XB, CI and TCI selections register relays are operated. When the CI relay operates, the PG relay closes its back contact, after approximately .069 seconds, as described in detail later. Due to the XB relay operated, the C and C' relays operate in series when the DRL relay operates. Due to the TCI relay operated,the FO-1 relay operates when the S-6 relay operates. This causes the FO-2 relay to operate releasing the FO-3 and RC relays. On a call indicator call,it is necessary to hold the trunk path open and delay the start of pulsing until all the required digits have been dialed. The FO-3 relay released as above accomplishes this. On this type of a call indicator call, to an office with four digit numbers only, there is no necessity to delay the sender for a possible extra digit and the marker consequently operates the SD and SD-1 selection register relays as in a full selector call. This permits the call to proceed when the units digit is dialed, as the U hold magnet operates relay UL-1, and UL-2 with the C, SD and SD-1 relays operated, operates STB and STB' in series, for any digits recorded on the

TH, H and T registers, as previously described for a call to crossbar. The STB' relay operates STL, which releases FO-1, then FO-2 releases, RC operates, and FO-3 operates for trunk test. At this point in the call, the following relays and magnets are operated: F-00 or F-10, CS-, ON1, ON2, ON3, AV3, OF2, SR, SR1, L, L1, L2, RA1, AL1, AL2, CL, RV-1, RV-2, RV-3, HL, UL-1, UL-2, STB, STB', STL, DST, selection register relays as required, DRL, C, C', S-6, S-6', RC, FO3, and hold magnets F, A, B, C, TH, H, T and U, OS(4-1)(2-1).

TRUNK TEST - OS(6-2)

The TG relay operates. (FO-3), OS(4-2). The battery and ground to operate the TG relay are furnished at the tip and ring, respectively, of the call indicator trunk circuit, and are connected to the FT and FR leads of the sender through the trunk and office link frames and the sender link, the originating circuits having been closed through to the trunk as described for a full selector call. The 14,500-ohm resistance is not included in this path, consequently the TG relay operates either on 48 or 24-volt battery. The required compensating resistance is used, controlled by the CR-1 and CR-2 selection register relays. The above operation is delayed until the STL relay operates upon the dialing of the units digit, as previously described. The TG-1 relay operates, OS( ) and TG-2 relay operates. A holding path is closed for the TG-1 relay. The TG-6 relay operates and locks. The CI-1 relay operates and locks. Ground is connected to the M resistance. This ground is for use with the PG relay, described below. The CI-1 relay operates the CI-2, OS(3-1). A holding path is closed for the TG relay. The OF relay is short-circuited by the CI-2. The OF relay is short-circuited to prevent it from responding to a momentary false overflow indication, OS(4-2) which may occur due to the trunk being disconnected from its previous connection after being seized on this call. The CI-1 and CI-2 relays are slow operate to allow time for the OF relay to operate, before its short-circuit is connected, on an actual distant office overflow or telltale or a trunk wired reversed. The PG-1 relay operates to the CI-1, OS(3-1). The PG-3 relay is short-circuited. The PG-1 operates the PG-2 relay which locks. The PG relay, is assumed to have closed its back contact.

TRUNK ASSIGNED - OS(6-2)

When the TG relay is bridged across the fundamental leads, a relay in the P.C.I. trunk circuit operates to signal the manual operator. She depresses the assignment key which opens the tip and ring of the trunk at the manual office. This causes the following to take place in the sender:

Sender TG relay releases. The condenser-resistance bridge about the winding of relay TG absorbs its discharge to prevent transmission of a false pulse. The TG-1 relay releases. The TG-1 relay is slow release to prevent a false assignment in case TG is momentarily released, which may happen if the trunk is still connected to a subscriber's line from the previous connection, and he should hang up the receiver while the sender is awaiting assignment. The TG-1 relay cannot release until CI-2 and PG-2 have both operated, to be sure that the pulsing circuit is ready to send pulses. The TG-2 relay releases and ground is connected to the FR and FT leads. The SP relay operates when TG-2 releases. The GR relay operates and ground is disconnected from the FT lead.

FIRST PULSE OF STATIONS DIGIT

The circuit is now in the position for transmitting the first pulse of the first digit. Under the assumed condition that the call is a direct call to an office having four digit numbers only, a zero is transmitted first as the stations or ten-thousands digit. This digit requires that the first and third pulse positions be open and that light negative pulses be transmitted in the second and fourth positions. For an open pulse, the sender connects ground to both the FT and FR leads, to short-circuit the trunk and thereby guard against false pulses due to the capacity of the cable pair. Shortly thereafter, controlled by the slightly slow operate GR relay, it removes the ground from the FT lead, leaving ground connected to the FR lead for the duration of the pulse position. The battery through 6500 ohms connected to the FR lead at this time is ineffective as it is short-circuited.

PG RELAY - OS(3-1)

The PG relay is a non-biased condenser-timed polarized relay. It cannot be said to operate and release, but it closes its front contact when energized in one direction by its primary winding, closes its back contact when energized in the other direction by its primary winding, and remains on either contact or between the contacts when not energized. When current is first closed through the primary winding in either direction,its force is more than neutralized by an opposing current in its secondary winding, the source of which is the charge or discharge of the timing condenser. When the condenser has been charged or discharged, current ceases to flow in the secondary, and the primary causes the armature to move over from one contact to the other. The actual time of operation varies somewhat with variations in voltage, resistance and relay adjustment. It averages about .069 second per single operation in one direction. Jack PG affords a means to patch the windingsof relay PG separately to a relay test set.

Operation of the CI relay, as stated above, causes the PG relay to close its back contact after a time interval. This is accomplished by the closure of opposing parallel paths from ground at the CI relay operated, through normal contacts of the SP relay, through both windings of the PG relay in parallel, the primary winding being connected to battery through part of the M resistance and the secondary winding being connected to the PG condenser which has a negative charge. The path through the primary winding is in the release direction of the relay, and the path through the secondary winding is in the operate direction.

At first the effect of the secondary winding is stronger, but as the condenser discharges,the current in the secondary is decreased, until the effect of the primary becomes stronger, causing the relay to close its back contact. When the CI-1 relay operates, it connects ground to the M resistance. This performs no function at the moment, being used later during the transmission of pulses. The CI-1 relay also connects ground to the armature of the PG relay, operating the PG-1 relay.

When the SP relay operates to start the transmission of pulses, it disconnects the ground at the CI relay and connects in its place, the front contact of the PG relay. Removal of the CI relay ground permits battery through the L resistance to flow through the primary winding of the PG relay, in the operate direction, through a winding of the M resistance to ground at the CI-1 relay, and sets up an opposing current from the same battery through the secondary winding, charging the condenser. At first the effect of the secondary winding is stronger and the back contact is held closed, but as the condenser charges, the current in the secondary is decreased, until the effect of the primary becomes stronger, causing the relay to break its back contact and close its front contact.

The CI-1 and SP relays having been operated, ground is now connected to the armature of the PG relay, and its front contact is connected to the L resistance. Closure of the front contact consequently, grounds out the 300-ohm battery and so starts opposing currents in the two windings as before, the current in the primary winding being in the release direction, its effect, however, being delayed until the condenser is sufficiently discharged.

The PG relay continues to operate and release in this manner during the transmission of pulses, and with the aid of the PG-1, PG-2 and PG-3 relays, closes the path required for the four pulse positions for each digit, as described later. Pulses are transmitted while the opposing currents are flowing in the windings of the PG relay, each pulse being connected to the fundamental leads for approximately .069 second, which is the length of time required to charge or discharge the PG condenser to the point at which the primary winding of the PG relay is effective. It can be seen that the PG relay is held on its back contact, while the PG condenser is charging and on the front contact while the PG condenser is discharging.

SECOND PULSE

After the time interval required to operate the PG relay, the first pulse is disconnected and the second is connected as follows:

The PG relay operates to the SP, and the PG-1 relay releases. Ground is removed from the FR lead and connected to the FT lead. The GR relay releases and an additional ground is connected to the FT lead. The PG-3 relay operates due to its short-circuit being removed. The circuit is now in the position for transmitting the second pulse of the stations digit. This is a light negative pulse under the assumed condition that a zero is being transmitted, and is connected due to the release of the PG-1 relay. Release of this relay removed the short-circuit from the 6500-ohm battery connected to the FR lead, permitting it to be effective, and connected ground to the FT lead.

THIRD PULSE

After the time interval required to release the PG relay, the second pulse is disconnected and the third pulse is connected as follows:

The PG relay releases and PG-1 relay operates. Ground is connected to the FR lead. The GR relay operates to the PG-1. Ground is removed from the FT lead. The PG-2 relay is short-circuited and releases due to the PG-1. A holding path is closed for the PG-3 relay. The STA relay operates and locks when the PG-2 releases. The STA' relay is short-circuited. The 12 relay operates, if the thousands digit is 6 or 7. The 12 relay operates at this time, if required, to prepare for sending the first two pulses for the thousands digit. This relay is used for any digit requiring a positive pulse in the first pulse position and a heavy negative pulse in the second position.

The third pulse of the stations digit is now sent, as described for the first pulse, ground being connected to both the FT and FR leads, and then removed from the FT lead under control of the slow operate GR relay. The battery through 6500-ohms resistance connected to the FR lead at this time is ineffective as it is short-circuited.

FOURTH PULSE

After the time interval, the third pulse is disconnected and the fourth pulse is connected as follows:

The PG relay operates and the PG-1 relay releases. Ground is removed from the FR lead and connected to the FT lead. The GR relay releases. An additional ground is connected to the FT lead. The PG-3 relay releases. The PT relay operates, if the thousands digit is 2 or 3, or if the 12 relay is operated. The PT relay is used to transmit positive pulses. It operates at this time, if required, to prepare for a positive pulse in the first pulse position of the thousands digit. It connects battery through 6500 ohms to the FT lead, this battery, however, being ineffective at this time as it is short-circuited.

The fourth pulse of the first digit is now sent, as described for the second pulse, the PG-1 relay, in releasing, removing the short-circuit from the 6500-ohm battery connected to the FR lead and connecting ground to the FT lead.

FIRST PULSE OF THOUSANDS DIGIT

The PG relay releases after its time interval and the PG-1 relay operates. Ground is connected to the FR lead and the PG-3 relay is short-circuited. The GR relay operates, the PG-2 relay operates and locks. The PR relay operates, if the thousands digit is 4 or 5, or if the 12 relay is operated. The PR relay is used to transmit heavy negative pulses. It operates at this time, if required, to prepare for a heavy negative pulse in the second position for thousands. It connects battery through 115 ohms in parallel with the 6500-ohm battery used for light negative pulses. These batteries are ineffective at this time, however, as they are short-circuited. The PG-2 operates the STA'. The 34 relay operates, if the thousands digit is 9. The 34 relay operates at this time, if required, to prepare for sending the last two pulses for the thousands digit. This relay is used for any digit requiring a positive pulse in the third position and a heavy negative pulse in the fourth position.

The first pulse of the thousands digit is transmitted at this time, due to operation of the PG-1 relay. It is a positive pulse if the PT relay is operated. In this case, battery through 6500-ohms resistance is connected through operated contacts of the PT relay to the FT lead, and ground at the PG-1 relay operated is connected to the FR lead. The ground at the GR relay contacts does not interfere, as the PT relay operated disconnects it from the fundamental. If the PT relay is normal, the positive pulse is not sent. Both sides of the trunk are grounded initially, the ground being removed from the FT lead when the slow operate GR relay operates, as previously described.

SECOND PULSE

The PG relay operates, after its time interval, and the PG-1 relay releases. Ground is removed from the FR lead and connected to the FT lead. The GR relay releases. An additional ground is connected to the FT lead, and PG-1 operates the PG-3 relay. Due to its short-circuit being removed, the PT relay releases, if operated, or the PT relay operates, if the thousands digit is 8, or if the 34 relay is operated. The PT relay operates at this time, if required, to prepare for a positive pulse in the third position. It disconnects the ground at the GR relay contacts and connects instead, battery through 6500-ohms resistance.

The second pulse of the thousands digit is transmitted at this time. It is a heavy negative pulse if the PR relay is operated, otherwise it is a light negative pulse. It is effective when the PG-1 relay releases, removing the short-circuiting ground from the FR lead and connecting it to the FT lead.

THIRD PULSE

The PG relay releases after its time interval, and the PG-1 relay operates. Ground is connected to the FR lead. The GR relay operates from the PG-1. The PG-2 relay is short-circuited and releases. A holding path is closed for the PG-3 relay. The PR relay releases if operated by PG-2 releasing. The PR relay operates, if the thousands digit is 1, 3, 5 or 7, or if the 34 relay is operated. The PR relay operates at this time, if required, to prepare for a heavy negative pulse in the fourth position. The TH relay operates and locks. The TH' relay is short-circuited and the 12 relay releases, if operated, or the 12 relay operates, if the hundreds digit is 3 or 8. The 12 relay operates at this time, if required, to prepare for sending the first two pulses for the hundreds digit.

The third pulse of the thousands digit is sent at this time, due to operation of the PG-1 relay. It is a positive pulse if the PT relay is operated, or open if the PT relay is normal, as previously described.

FOURTH PULSE

The PG relay operates, after its time interval, and the PG-1 relay releases. Ground is removed from the FR lead and connected to the FT lead. The GR relay releases, the PG-3 relay releases, and the PT relay releases, if operated, or the PT relay operates if the hundreds digit is 1 or 6, or if the 12 relay is operated. The PT relay operates at this time, if required, to prepare for a positive pulse in the first position of the hundreds digit. It disconnects the ground at the GR relay contacts and connects instead, battery through 6500-ohms resistance. The fourth pulse of the thousands digit is transmitted at this time. It is a heavy negative pulse if the PR relay is operated, otherwise it is a light negative pulse. It is effective when the PG-1 relay releases, removing the short-circuiting ground from the FR lead and connecting it to the FT lead.

HUNDREDS, TENS AND UNITS DIGITS

The transmission of these digits is similar to the circuit operations described for the stations and thousands digits. For each digit, the PG-1 relay is operated while the back contact of the PG relay is closed, or during the first and third pulse positions. The PG-2 relay is operated during the first and second pulse positions of each digit and the PG-3 relay is operated on the second and third. Release and operation of the PG-2 relay cause the P.C.I. progress relays to operate in order for connecting the registers to the pulse relays, the STA, TH, H, T and U relays operating at the beginning of the third pulse for their respective digits, and the STA', TH', H', T' and U' relays operating at the beginning of the first pulse of the succeeding digit. The PT and PR relays operate as before, whenever positive and heavy negative pulses, respectively, are required. The PT and PR relays operate in all cases one pulse ahead of the pulse they are to transmit. The PT relay operates at the beginning of the fourth pulse of a digit to prepare for the first pulse of the following digit. It also operates to the beginning of the second pulse of a digit to prepare for the third pulse. The PR relay operates at the beginning of the first and third pulses to prepare for the second and fourth, respectively. This arrangement insures that these relays will be fully operated by the time the pulse starts. The 12 relay operates at the beginning of the third pulse of a digit if the succeeding digit requires it. The 34 relay operates at the beginning of the first pulse of a digit if that digit requires it. This insures that the operating path for the PT (and PR) relays will be closed in time, the operating paths for the 12 and 34 relays being closed one pulse position ahead of the operating paths for the PT relay. On types of calls in which a party letter, the ten-thousands digit of a five digit number, or the "A" digit of the office code is transmitted first, the initial operating paths, if required, for the 12, 34 and PT relays are closed when the CI-1 relay operates, and for the PR relay on the first operation of the PG-2 relay. Battery through 6500-ohms resistance is connected to the FR lead continuously during the transmission of pulses. Battery through 115 ohms is also connected while the PR relay is operated, and battery through 6500-ohms is connected to the FT lead while the PT relay is operated. The PG-1 relay, in operating and releasing, alternately grounds the FT and FR leads. This ground short-circuits any battery connected to the grounded lead, and completes the pulse from battery on the opposite lead, if required.

FINAL HEAVY POSITIVE PULSE

After the pulses for the number have been sent, the fundamental leads are grounded as for an open pulse. A final heavy positive pulse is then transmitted to complete the display at the called office (or advance a tandem sender on a tandem call) and to advance a distant office selector, if included in the routing, from selection beyond position to talking position. This pulse consists of closure of low resistance battery to the FT lead and ground to the FR lead, in the sender. It is of the same polarity as the reversed battery pulse received from panel or crossbar terminating equipment during incoming advance on a full selector call, and acts to advance a distant office selector in the same manner. The circuit advances as follows, after the fourth pulse for the units digit is sent.

The PG relay releases after its time interval, and the PG-1 relay operates. Ground is connected to the FR lead. The PG-3 relay is short-circuited, and the PG-2 relay operates and locks. The PR relay releases, if operated. The GR relay operates. (PG-1) Ground is removed from the FT lead. The U' relay operates, and the 34 relay releases, if operated. The FP relay operates. (U') Ground is removed from FR lead, and is connected to FT lead.

These operations caused ground to be connected to both of the fundamental leads, and then to be removed from the FR lead. Battery through 6500 ohms, and battery through 115 ohms is parallel, are connected to the FT lead, but are short-circuited. This condition obtains for the duration of one pulse and the following then takes place:

The PG relay operates, after its time interval, and the PG-1 relay releases. Ground is removed from the FT lead and connected to the FR lead. The PG-3 relay operates. Due to its short-circuit being removed, the GR relay releases. An additional ground is connected to the FR lead. Release of the PG-1 relay by removing the short-circuit from the 6500-ohm battery and the 115-ohm battery connected to the FT lead, and by connecting ground to the FR lead, causes the heavy positive pulse to be sent. The sender then restores to normal as described below.

DISCONNECTION OF SENDER

The PG relay releases, after its time interval, and the PG-2 relay is short-circuited and releases. A locking path is closed for the PG-3 relay. The AV relay operates and locks. FT and FR leads are opened. The AV-1 relay operates, and the CI-1 relay releases. Ground is disconnected from the M resistance. The SP, FP, PG-3 and CI-2 relays release. STB and STB' relays release. The circuit restores to normal from this point as in a full selector call, from operation of the AV-1 relay, except that the release of the OF, IA, STB, STB', FS-1, FS-2, FS-3, O, BO, and FO relays is omitted and as follows: The STA, STA', TH, TH', H and H' relays release. When the ON-1 relay releases, the T and T' relays release, and U and U' relays release.

STATION DELAY

Manual offices may have party lines, and may have numbers over 9999, the highest possible number being 10499. Numbers assigned to party lines are always four digit numbers, as the use of five digit numbers for such lines would require additional equipment for recording and transmitting a total of six digits. If the called office has five digit numbers or party lines, about four second is allowed for the dialing of the fifth numerical digit or party letter, after the units digit is dialed. This delay is introduced on all calls to offices having party lines, whether the particular number dialed requires it or not, and on calls to offices having five digit numbers if the first three numerical digits dialed are 100 to 104, indicating a possible five digit number. In any case, if the extra digit is not dialed, the call proceeds as for a four digit number at the expiration of the delay.

The delay is controlled by the SD and SD-1 selection register relays, which are operated by the marker to conform to the class of the called office, in accordance with the following table. The designations "A", "B", "C" and "D" are used to indicate the four types of delays.

STATION DELAY TABLE

Called Office	Delay	SD Relay	SD-1 Relay
Four Digit Numbers Only	None (C)	Operated	Operated
Four and Five Digit Numbers (No Party Lines)	On Numbers Beginning With 100 to 104 (B)	Operated	Normal
Four Digit Numbers and Party Lines	On all Calls (D)	Normal	Operated
Four and Five Digit Numbers and Party Lines	On all Calls (A)	Normal	Normal

A call to the first type of office has been described. Calls to the other three types of offices are described below.

FOUR AND FIVE DIGIT NUMBERS (NO PARTY LINES)

A call to an office of this type is similar to the P.C.I. call previously described, except that the SD-1 relay is normal and a delay is consequently introduced in some cases. There is no delay if the first three numerical digits dialed indicate that the number could not be a five digit number. In this case,crosspoints 0 or 2 to 9 on the thousands register, 1 to 9 on the hundreds register, or 5 to 9 on the tens register close a path to operate the STB and STB' relays when the UL-1 relay operates, the SD relay being operated. Any one of these crosspoints being closed shows that the first three numerical digits are other than 100 to 104 and that the number, in consequence, cannot be a five digit number. In this case,the STB' relay operates the STL relay and the call proceeds as described in the previous section.

If the first three numerical digits, however, are 100 to 104, there is no path to operate the STB and STB' relays directly, as the SD-1 relay is normal. In this case,trunk test is delayed as the STL relay is normal. The SD interrupter counts approximately four seconds, starting when the UL-1 relay operates, and then operates STB and STB' as follows, if the fifth numerical digit is not dialed.

The H relay operates. When the SD interrupter closes, the H' relay is short-circuited. The H' relay operates and the H relay locks, in series. When the SD interrupter opens, the T relay operates. When the SD interrupter closes, the T' relay is short-circuited. The T' relay operates and the T relay locks, in series. When the SD interrupter opens, the U relay operates. When the SD interrupter closes, the U' relay is short-circuited. The U' relay operates and the U relay locks, in series. When the SD interrupter opens, the STB relay operates. When the SD interrupter closes, the STB' relay is short-circuited. The STB' relay operates and the STB relay locks, in series. When the SD interrupter opens, the STL relay operates and locks. The H and H' relays release, the T and T' relays release, and U and U' relays release.

Under these conditions, with no fifth numerical digit dialed, the call proceeds as for a four digit number. If a fifth digit is dialed while time is being counted as above, it is recorded on the ST vertical of the crossbar switch. When the ST hold magnet operates, it operates the STA and STA' relays in series, this path being closed through crosspoints No. 1 on the TH register, No. 0 on the H register, and No. 0 to 4 on the T register, and contacts of the SD-1 relay normal. The STA relay operates the STL relay. This cancels any remaining allowed time by permitting trunk test to take place, and it prevents the STB and STB' relays from operating. If dialing of the fifth digit starts just before the expiration of the allowed time, the RA relay operated delays the operation of STL, thereby permitting proper registration of the digit. In this case when STA operates, it releases STB and STB', if they are operated. When pulses are sent with the STA and STA' relays already operated, the TH register is used first for the ten-thousands digit, the H register is then used for the thousands digit, etc. The STB and STB' relays are used with the ST register for sending the units digit. The final heavy positive pulse is sent as before. On a call of this type,the code for the ten-thousands digit (No. 1 crosspoint, TH register) is changed to add the required positive pulse and omit the heavy negative pulse that is closed otherwise. This is accomplished by the STB relay normal. The ST hold magnet, is operated, releases when the U hold magnet releases. Release of the ON-1 relay releases the STA and STA' relays and the RA-2, RA-3 and RA-4 relays, if operated due to dialing of the extra digit.

FOUR DIGIT NUMBER AND PARTY LINES

For this type of called office, the marker leaves the SD relay normal and operates the SD-1 relay. There is a delay on all calls, as there is no direct path to operate the STB and STB' relays when the units digit is dialed. The SD interrupter counts time as before and if no party letter is dialed, the STB and STB' relays are operated by the interrupter at the expiration of the allowed time. The call then proceeds as for a four digit number, a zero being transmitted first. If a party letter is dialed within the allowed time, it is recorded on the ST register as described for the other digits. Operation of the ST hold magnet operates the STB and STB' relays. Relay STB' operates STL and the call proceeds as for a four digit number except that the party letter is transmitted first, instead of a zero. The RA relay operated, by delaying operation of the STL relay, permits proper registration of the party letter if it is only partially registered at the expiration of the delay. Crosspoint contacts Nos. 9, 7, 5, and 6 closed, respectively, for recording the party letters W, R, J and M due to the location of these letters on the dial. These contacts are wired to close the correct pulses for the letters, which are different from the pulses for the numbers 9, 7, 5 and 6 when used for other digits. The ST hold magnet, if operated, releases when the U hold magnet releases. Release of the ON-1 relay releases the RA-2, RA-3 and RA-4 relays, if operated due to dialing of the stations digit.

FOUR AND FIVE DIGIT NUMBERS AND PARTY LINES

On calls to an office of this type, both the SD and SD-1 relays are normal and there is a delay on all calls. No numbers in the 1000 block are assigned as party lines in these offices, as if they were, the sender would not be able to distinguish between such party lines and five digit numbers. In this case,the SD interrupter counts time as before. If no fifth numerical digit or party letter is dialed, the STB and STB' relays operate at the end of the allowed time and the call proceeds as for a four digit number. If a party letter is dialed, the STB and STB' relays operate due to operation of the ST hold magnet. The call then proceeds as described above for a party line call, the party letter being transmitted first. If a fifth numerical digit is dialed, the STA and STA' relays operate when the ST hold magnet operates. This causes the number to be transmitted as a five digit number as previously described. The sender distinguishes between a party letter and a fifth numerical digit by means of the paths closed through the TH, H and T registers. If 100 to 104 is dialed on these registers, the extra digit is a fifth numerical digit, as this block is not used for party lines in these offices. Otherwise, the extra digit is a party letter.

TANDEM P.C.I. CALL

In a call to a mechanical tandem office, the office code is transmitted in addition to the called number. The call proceeds as for a direct call of any of the four classes except as follows:

During connection to the marker, the TGI and CI selection register relays are operated, and the XB is not operated. Due to the XB relay normal, the C and C' relays do not operate previous to pulsing. The trunk guard path is opened mechanically at a tandem sender circuit. When pulsing starts, the A, B and C digits are transmitted first, controlled by the A, B and C progress relays. The number is transmitted in the same manner as for a P.C.I. call. The A and A' relays release when the ON-1 relay releases. The A relay releases the B and B' relays, and the B relay releases the C and C'.

THREE DIGIT TANDEM P.C.I.

It is possible for the tandem sender to complete calls to a tandem P.C.I. office, which only require an office code. In this case the marker, when it returns its information to the sender, will operate the TCI, CI and OD relays. The OD relay causes the operation of the STB and STB' relays when the DRL relay operates. The STB' relay causes the STL relay to operate. This cancels any delay to allow dialing to be completed. The call then proceeds as a regular tandem P.C.I. call. The code is pulsed but due to the fact that no numerical registration is set in on the crossbar switch all zeros are sent for the number. The sender then disconnects as for a regular P.C.I. call.

STRAIGHTFORWARD CALLS

It is possible for an "A" switchboard operator to complete calls requiring the dialing of only three digits. There is no difference in the trunk used in this case. When the operator has dialed the third digit of the code, the tandem marker is called in as in a regular call. The marker recognizes the fact that the code is for a three digit call. From this point there are two possible procedures. The first is "Straightforward Direct". In this case the tandem sender will advance and release after "Trunk Test". The second is "Straightforward Through R.P. Tandem". This condition requires a second tandem office to complete the call. Both cases are outlined in the following text.

STRAIGHTFORWARD DIRECT - OS(4-4) SC-6

The "A" switchboard operator will dial three digits of the office code when she receives the start dialing signal. After the code has been dialed, the operator waits for an order tone. On receiving this tone she will pass the number orally.

The tandem marker in this case will take the office code and return to the sender an SO, TCI and OD indication. The marker will select the trunk in the usual manner. On the operation of the tandem sender DRL relay, the S6 and FTT relays operate. The release of the sender DC relay by the marker allows the S6' relay to operate. Trunk test, however, is made right in the sender. The FTT relay opened the FT and FR leads. The FTT relay supplied 600-ohm battery on its top contact and ground on its bottom contacts. This is necessary as a trunk test made to the trunk battery and ground would cause order tone to be returned before the tandem sender has completed its functions. The order tone is finally sent when the trunk is closed during trunk closure. Due to the internal trunk test, the TG, TG1 and TG2 relays operate. OS(6). The TG2 relay operates the AV relay advancing and disconnecting the sender in the usual manner.

STRAIGHTFORWARD THROUGH R.P. TANDEM

The "A" switchboard operator will proceed as for a "Straightforward Direct" call waiting for an order tone.

The tandem marker in this case will recognize the code as one routing through a "R.P. Tandem Office". The marker will now operate the SO relay but will operate the TW and TCI relays. Selections, relays for office selections are also operated. The OP1 relay operates when the DRL relay operates. Office test and selections are made when the marker disconnects, releasing the sender DC relay. Incoming trunk test is made operating the TG, TG1 and TG2 relays. The TG2 relay operates the OP, which locks and releases the slow release OP1. The OP1 relay released,operates the OP2 which locks and opens the fundamental circuit. The slow release OP1 relay delays the opening of the fundamental circuit to allow the distant R.P. tandem office circuits time to advance. The OP2 relay releases the TG1 relay. The TG1 releases the TG2 which releases the OP relay. The OP2 operated with the OP and OP1 relays release, provides a path to operate the AV relay. This causes the advance and release of the sender.

R. P. SENDER

R. P. SENDER

REVERTIVE PULSE SENDER SD-25359

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REVERTIVE PULSE SENDER

SD-25359-01

PURPOSE OF CIRCUIT

This circuit is used in a crossbar tandem office to complete calls from panel and No. 1 crossbar offices to panel, manual, No. 1 crossbar, and step-by-step offices.

DESCRIPTION OF EQUIPMENT

A revertive pulse sender circuit consists of relays and a 100 point 4 wire crossbar switch. There are five sender circuits per sender frame, designated 0 to 4 from the bottom up. Each sender is individually connected to the sender link and controller circuit by 12 leads, of which 8 appear at crosspoints of the sender link secondary switches. These 8 leads are designated T, R, FT, FR, S, DC, D and CO. The other four individual leads are designated SB, SC, HM and BS.

The senders mounted on one frame may or may not constitute a subgroup of senders. Each subgroup of 5 or less senders is connected to the sender link and controller circuit by 15 leads, in addition to the 12 individual leads for each sender. These 15 leads are connected into any one sender of the subgroup for a short time when it is first seized for service. They consist of leads GS, SL, RL, GA, GB and F0 to F9, F00 and F10 for registering the trunk link frame indication.

There are about 41 leads from each sender to its connector circuit used for transmitting information back and forth between the sender and the marker and for mutual control.

The elements of the sender may be roughly divided, in respect to their functions, into eight principal parts, as follows:

CONTROL RELAYS OS (21)

This controls the connections between the sender, the sender link and controller circuit and the tandem trunk; and the connections between the tandem sender, the marker connector and the marker. It consists of the following relays: SC1 and SC2 used for sender control, ON1 and ON2 used to supply off-normal grounds, MB used for making sender busy, TC, CK1, CK2 and CK3 used for trunk closure, RL used to record a release, TR, TR1, TR2, and TR3 used to record a trouble release, D-C for decoder control, AV2 and AV3 for advance, DST for decoder start and DRL for decoder release.

PULSING CIRCUIT OS (22)

This generates and counts the pulses which are sent for each registration to satisfy the counting relays in the originating sender and generates a reverse pulse to advance the originating sender when selections have been completed. It consists of the following relays: L, L1, L2, L3, L4 and L5 which are line relays and are used to start registration and aid in the counting of the pulses generated, STA which performs the normal stepper relay functions, GR used for grounding the fundamental circuit as the panel system commutators do, P1, P2, P3, P4, P5 and P6 which count the pulses that have been generated, TT used for indicating a telltale condition, which in this sender is the generation of eleven pulses, RV1, RV2, RV3, RV4, RV5, RV6 and RV7 which are used to aid in the transmission of a reverse battery and ground pulse. OS(21)

FRAME SELECTION REGISTER OS (21)

This registers the office brush and office group registration and the five registrations sent by the originating sender, they being incoming brush and group, final brush, tens and units selections. It also registers the number of the trunk link frame involved. A crossbar switch is used for this registration and there are relays used to control the action of the switch. The switch has eight verticals designated F for frame unit and OB, OG, IB, IG, FB, FT and FU for the selections. The full complement of relays is as follows: F-00 and F-10 used to record the tens digit of the trunk link frame number, SM used in conjunction with the select magnets, XSM used to indicate the false operation of two select magnets, HM used to indicate the operation of the crossbar switch hold magnets, and RA-1 and RA-2 used to advance the register circuit. If there are not more than ten trunk link frames relays F00 and F10 are omitted.

SELECTION RELAYS OS(24)

These are set up by the marker to record the class of call, the compensating resistances required, office brush and group, and other details of the routing which the sender requires in order to do its part in establishing a connection to the called station. It consists of the following relays: a compensating resistance CR1, CR2 and CR5, crossbar call XB, panel call indicator call CI vacant code OD and XB, OB and OG.

FUNDAMENTAL CIRCUIT OS(22)

This circuit consists of the following relays which are either cut into the fundamental to recognize pulses, direct battery or reversed battery from the distant end of trunks or are supplementary to such relays: stepper, STB, trunk guard TG, TG1 and TG2, marginal trunk guard MTG, overflow OF and OF1, supervisory S and heavy positive pulse P.

COUNTING RELAYS OS(23-1)

These are operated in successive pairs by the pulsing of relay STB, which is energized by the revertive pulses generated by distant panel selectors or crossbar terminating senders. The number of pairs operated for a particular selection is determined by the number of pulses required. The relays consist of counting relays 0, BO, FO and 1 and 1' to 6 and 6' and release counter RC, which assists in the use of the counting relays for a second time on a selection requiring more than six pulses.

SELECTION SEQUENCE CIRCUIT OS(23-1)

This makes the proper internal connections in the sender in a definite order as the sender progresses through its successive selections and trunk tests. It consists of the following relays: Selection S-1 and S-1' to S-7 and S-7', full selector FS1 and FS2, incoming advance IA and FO1, FO2 and FO3 which are generally supplementary to counting relay FO.

TIMING CIRCUIT

The timing circuit measures off maximum allowed time for the reception of registration, completing selections and for the sender to release. If this allowable time is exceeded the timing circuit takes proper action to dispose of the call.

SELECTION OF SENDER

OS- (21)

SC1

The sender link and controller in its functions selects a sender subgroup and removes it from service on other sender link frames. Some common leads of the controller are then connected to the subgroup by the operation of the C multi-contact relay and an idle sender is selected. The idle sender is selected by the operation of its S relay, which then connects ground to the SC lead operating the SC1 relay.

The SC1 relay connects the S lead to the SL lead for the purpose of a sleeve continuity between the link crosspoints and the sender. If this continuity is completed the link controller SL relay operates as a check.

OS-(21)

HM LEAD

The operation of the SC1 relay grounds the HM lead to the sender link at which point it connects to the GH lead for operating the sender link hold magnets, thereby connecting the calling trunk to the selected sender.

REGISTRATION OF TRUNK LINK FRAME

OS- (21)

SC2

The tandem trunk circuits appearing on a sender link frame also appear on a corresponding trunk link frame, through which the decoder marker completes the outgoing connection to a trunk. To assist the marker in this function, the sender link and controller circuit records in the sender, for transmission to the marker, the number of the trunk link frame involved.

The number of trunk link frames in an office is limited to twenty, numbered from 0 to 19 or as required. The tens digit of the frame number is indicated by a ground from the sender link and controller circuit on the F00 or F10 lead, and is recorded in the sender by operation of the corresponding F relay. The units digit is indicated by a ground on one of the leads F-0 to F-9, and is recorded on the F vertical of the crossbar switch.

The F10 lead, if grounded, indicates to the marker that the tens digit of the frame number is 1. If not grounded, it indicates zero. Either relay operated grounds a lead corresponding to its designation toward the marker connector.

GB or GA

The GB or GA relay is used to indicate to the marker that the office code (recorded later), is in the first group of fifty codes or the second group of fifty codes, in a possible one hundred. This indication is sent from the sender link and controller preferred trunk group. The GB relay indicates group below fifty and the GA relay group above fifty.

The office brush and office group selections sent out from the originating sender can only give a maximum of 50 combinations, since there are five different brush selections and ten different group selections. A crossbar tandem sender, however, may be equipped to register 100 revertive codes by utilization of either the GB lead for codes 00-49 or the GA lead for codes 50-99.

OS- (21)

SELECT MAGNET

There are ten select magnets, numbered 0 to 9. The one to operate corresponds in number to one of the F-0 to 9 leads that is grounded by the sender link C relay. Battery for the select magnets is supplied through the winding of the XSM relay which is marginal and will not operate except when two select magnets are grounded at the same time. On this call it is assumed that only one select magnet is grounded and therefore the XSM relay does not operate.

If the F00 relay is operated, the number of the select magnet operated indicates the number of the trunk link frame connected and therefore the number of the trunk link frame involved on this call.

If the F10 relay is operated, the frame number is 10 higher than the number of the select magnet.

RV3 OS(21)

The ground which operates the F00 or F10 is extended through the operated contacts of the relay to operate the RV3 relay.

OS- (21)

SM

The SM relay when operated connects a shunt ground on the STA relay which will prevent its operation when the fundamental circuit is closed by the ON1 relay later.

OS- (21)

RA1

The ground which operates the F00 or F10 is extended through the operated contacts of the relay to operate the RA1 relay after the operation of the SM relay. The RA2 relay can not operate at this time since its operating battery is being shunted through its released contacts.

PREPARATION FOR ORIGINATING SELECTIONS

OS- (21)

ON1

The ON1 relay operates as a check that the sender link crosspoint closure was successful. It receives its operating ground from the GS lead which is supplied through the operated contacts of the sender link controller SL and ST relays.

The ON1 relay when operated connects ground to the SB punching, which is used for the connection of a holding time recorder when required.

The ON1 relay grounds the SB lead to the sender subgroup circuit operating the SB relay for indicating its busy condition in the group.

OS- (22)

L

The L relay battery, and ground from the SM relay are connected in parallel with the battery and ground from the tandem trunk A relay, which is holding the STP relay in the originating sender for office brush registration. This is done at this time in order to prevent any interruption of battery and ground, due to tandem trunk functions described later, which might cause the registration of a false pulse in the originating sender.

The operating circuit for the L relay is as follows: battery through the winding of L relay in parallel with the BN resistance battery on normal contacts of the L1 relay, operated contacts of RV3, normal contacts of SB1, RV1, SP, CI1, PA, SA, CI1, CI2, and RV7 relays; operated contacts of ON1 relay to the T lead to sender link crosspoints to the originating office, through winding of originating sender STP and OF relays to the R lead, through operated link crosspoints to tandem sender, operated contacts of ON1 relay, normal contacts of RV7, CI2, CI1, SA, PA, CI1, RV4 and RV2 relays, to ground on the normal contacts of the L1 and L2 relays.

The sender circuit STA relay is shunted at this time by the normal contacts of the L1 and L2 relays.

The L relay operates with the non-inductive BN resistance shunting its active winding. This is unimportant on the first selection, but on later selections the distant STP relay operates in series with it, and the non-inductive resistance serves to smooth out the descending side of a cable capacity surge, which has a tendency to operate the STP relay of the originating sender momentarily. The L1 relay in operating removes this non-inductive resistance from the circuit in order to speed up the subsequent operations of the distant STP relay.

The L1 relay operates through a back contact of the L2 relay and a front contact of the SM relay. The L1 locks, operates the L2 relay and disconnects the BN resistance. The purpose of these connections is to prevent a selection from starting until the previous selection has been registered.

The reason for having parallel ground connections to the R lead from the normal contacts of the L1 and L2 relays is as follows: on their operation, ground must be finally removed by the L2 relay because if it were removed by the L1 relay at the same time L1 relay breaks off non-inductive shunt, the STP of the originating sender might make a false release from having too much inductance thrown into its circuit at one time. On the other hand, on the release of the L1 and L2 relays, release of the L2 relay is delayed due to slow release and it is necessary to short-circuit the STA relay at once when the L and L1 relays release to prevent a chance of starting the next selection prematurely.

REGISTERING FRAME NUMBER

OS-(21)

ON2

If the subgroup circuit SB relay operates it connects ground to the BS lead. The ON2 relay operates from the BS lead, provided that the RA1 relay is operated, (indicating that the register advance relays are set in condition for the start of the call) the XSM relay is normal (indicating only one select magnet operated, which is the assumed condition), that either the F00 or F10 relay is normal and that the GB relay is operated and the GA relay normal or the GB relay normal and the GA relay operated. From the above it will be seen that this operating circuit checks that the register advance relays have functioned, that only one frame indication has been received and that only one of the group of fifty codes are registered.

The ON2 relay connects ground to the S lead to lock in the sender link hold magnets under control of the sender. This same ground holds the sender link SL relay until the SC1 relay releases. It also connects ground to the sender link RL lead to start the release of the sender link controller.

The ON2 relay connects ground to the CO lead, through the sender link crosspoints to the tandem trunk, operating the T relay. The T relay in operating removes the battery and ground from the tip and ring leads, releasing the trunk A relay. This has no effect on the originating sender since the sender L relay battery and ground on the operated contacts of the SM relay is holding the originating sender STP relay, awaiting office brush selection.

OS- (21)

SC2

When the SC2 relay releases, the F leads are disconnected from the select magnets.

The operated select magnet does not release as it and the operated SM relay are locked until both the FM and L2 relays operate. This will occur when the FR hold magnet operates.

OS- (21)

FR HOLD MAGNET

When the RA1 relay previously operated, it connected the winding of the FR hold magnet to both windings of the HM relay. These windings are differentially connected and so proportioned that the relay will not operate or hold with the same current in both windings as before a hold magnet is connected to them; nor will it operate with the combined current through the hold magnet and the secondary winding passing through the primary winding. The hold magnet does operate, however, under the latter condition, which occurs as soon as the ON2 relay operates and connects ground to the primary winding of the HM relay.

The crosspoint contacts are closed at the level of the operated select magnet. The closure of the crosspoint contacts connects ground to a combination of numbered F leads to the marker connector.

OS- (21)

HM

When the FR hold magnet closes its off-normal contacts, it locks and operates the HM relay in parallel. The FR hold magnet locks to the ON1 relay and extends its locking ground to the primary winding of the HM relay, thereby short-circuiting that winding and allowing the HM relay to operate on its secondary winding.

OS- (21)

SM

In order for the SM relay and operated select magnet to release, both the HM and L2 relays must be operated, the HM due to the frame indication having been registered and the L2 indicating that the fundamental is still closed to the originating sender.

OS- (21)

RA2

The SM relay in releasing removes the shunt from the RA2 relay which operates in parallel to the locking ground of the RA1 relay.

PREPARATION FOR EACH ORIGINATING SELECTION

OS- (22)

STA

The originating sender is ready for any selection or for the receipt of a reverse battery pulse when its stepper relay and its polarized overflow relay are connected in series with the tip and ring of the tandem trunk.

It gets ready for the first selection before the tandem sender is seized, this condition of being ready is the cause of the tandem trunk starting the sender link and controller to seize a tandem sender and attach it to the tandem trunk.

When the originating sender has received enough pulses on any selection to satisfy its demand, it opens the fundamental circuit.

The tandem sender is ready for a selection when the operating winding of the L relay is connected to the T lead without being shunted by the non-inductive BN resistance on the normal contacts of the L1 relay, and the winding of the STA relay is connected to the R lead without being shunted by a direct ground from the normal contacts of the L1 and L2 relays or by ground from the tandem trunk circuit T relay normal. Although ready when in that condition, it will not actually begin pulsing on the first selection until the tandem trunk T relay has operated and removed the trunk circuit battery and ground, or on any subsequent selection until the originating sender is ready with its circuit closed through its STP and OF relay windings.

To get ready for the fist selection the ON1 relay must be operated to cut through the T and R leads to the L and STA relays. The reason for this is to insure against interference with another tandem sender in case of a double connection at the sender link. The ON1 relay does not operate until the sender link and controller circuit has satisfied itself that there is no double connection.

As soon as the SM relay releases, the last shunting ground is removed from the STA relay which then operated for the first pulse.

PULSES GENERATED AND COUNTED

OS- (22)

GR

The GR relay when operated connects ground to the T lead which holds the tandem sender L relay operated, shunts down the originating sender STP relay and returns on the R lead to shunt the tandem sender STA relay in series. This operation and release of the two stepper relays constitutes the first pulse. This pulsing continues until the originating sender opens the fundamental circuit. The speed of pulsing depends upon the length of the trunk, a long trunk slowing down the speed of operation of the two stepper relays to about the same degree.

In order to extend the life of the contacts of the tandem sender STA relay the direction of current flow is reversed by the even or odd number of the trunk link frame. This is cared for by the crosspoint closure on the FR vertical of the sender crossbar switch.

The originating sender counts the pulses on its counting relays and breaks the circuit, stopping the generation of pulses when a predetermined number from 1 to 10 has been generated and counted. In case of an abandoned call or a trouble condition the sender may fail to count the pulses and to break the circuit after the predetermined number has been generated. In that case, the tandem sender will generate eleven pulses before stopping of itself.

OS- (22)

L3, L4 & L5

The tandem sender counts the pulses on the P-1 to P-6 relays, actuating them by the L3, L4 and L5 relays. The periodical operation and release of the

GR relay causes the two stepper relays to release and reoperate and also causes the operation and release of the L3, L4 and L5 relays in a recurrent cycle every two pulses. The operation of the GR relay on the first or any odd numbered pulse operates the L3 relay; its release permits the L5 relay to operate in series with the L3 relay. The operation of the GR relay on the second or any even numbered pulse, operates the L4 relay in series with the secondary winding of the L5 relay, whereupon the L3 relay releases but the L5 relay holds. Release of the GR relay releases the L4 and L5 relays. Therefore, the L5 relay is operated at the end of each odd pulse and releases at the end of each even pulse.

The ground for holding the L3 and L5 relays in series is furnished by make contacts of the L1 and L2 relays so that the L3 and L5 relays will release after the last pulse of a selection, should they be operated. The reason for connecting these make contacts of the L1 and L2 relays in parallel is as follows: the L1 relay operates first and by having it supply a locking ground there is better assurance that it will be ready in time than in reliance were placed on a possible vibrating contact of the L2 relay alone. On the other hand, on the release of the L1 and L2 relays, the L2 relay is delayed and it is necessary to hold the locking ground until it releases or else an additional P relay might be operated from the normal contact of the L5 relay.

The L4 relay does not release at the time the L3 relay releases since it is held operated in series with the locking circuit of the L5 relay. The reason for locking the L4 relay to the L3 relay operated, is to prevent the possibility of registering a false pulse. If the L3 relay were slow or failed to release, the release of the L4 relay would cause the reoperation of the L5 relay and thereby register two pulses instead of one.

At the end of the second pulse the L3, L4 and L5 relays are released, which was the position of these relays at the start of pulsing, the P2 relay is operated and the P1 relay has released.

OS- (22)

P1 to P6

There are six P- relays furnished in the tandem sender for counting the pulses generated. The P relays left locked up after each pulse, any one of which may be the last pulse of a selection, are as follows:

Pulse	Relays
1	P1
2	P2
3	P3
4	P4
5	P5
6	P5P6
7	P1P6
8	P2P6
9	P3P6
10	P4P6
11	P4P6TT

The L5 relay, operated and released on successive pulses, closes two leads alternately to the pulse counting relays P1 to P6 causing them to operate and release as indicated in the following chart:

Pulse	GR	L3	L4	L5	P1	P2	P3	P4	P5	P6	TT
1st	O	O									
1st	R	H		O	O						
2nd	O	R	O	H	H						
2nd	R		R	R	R	O					
3rd	O	O		S/C		H					
3rd	R	H		O		R	O				
4th	O	R	O	H			H				
4th	R		R	R			R	O			
5th	O	O		S/C				H			
5th	R	H		O				R	O		
6th	O	R	O	H					H		
6th	R		R	R					H	O	
7th	O	O		S/C					H	H	
7th	R	H		O	O				R	H	
8th	O	R	O	H	H					H	
8th	R		R	R	R	O				H	
9th	O	O		S/C		H				H	
9th	R	H		O		R	O			H	
10th	O	R	O	H			H			H	
10th	R		R	R			R	O		H	
11th	O	O		S/C				H		H	
11th	R	H		O				H		H	O

O - Operate
R - Release

The operating ground for the P relays is supplied through parallel make contacts of the L1 and L2 relays for the following reasons: through the make contacts of the L1 relay in order to have a non-chattering circuit ready early enough and through the operated contacts of the L2 relay to allow sufficient time to operate the last P relay on the last pulse of a selection. For the latter reason the L2 relay is made slow release while the L1 relay is fast release because it must release before the L relay operates for the next selection.

The locking ground for the P relays is supplied through a normal contact of the SM relay. The contact of the SM relay holds the locking circuit until the select magnet is operated and locked.

OFFICE BRUSH SELECTION AND REGISTRATION

OS- (22)

L

The office brush selection is pulsed by the GR relay as already explained and when the originating sender has been satisfied the fundamental circuit is opened. When the GR relay releases at the end of the last pulse, the L, L1 and

L2 relays release. Upon the release of the L2 relay one of the select magnets in the group 0 to 4 operate, followed by the operation of the SM relay. The select magnet to operate is that one whose number is one less than the pulses counted. The RA1 relay then releases operating the OB hold magnet, which closes the crosspoint contacts at the level of the operated select magnet.

The tandem sender L relay can reoperate as soon as the originating sender closes the fundamental for office group selection. The L1 and L2 relay can not reoperate, even though the L relay does operate immediately, until the SM relay operates on the registration of the previous selection.

OS- (22)

L3, L4, & L5

The L3 and L5 relays if operated at the end of a series of pulses, release, upon the release of the L2 relay, while the L4 and L5 relay if operated at the end of a series of pulses, releases, upon the release of the GR relay.

OS- (22)

SEL. MAGNET

The operating circuits for the select magnets are taken through four different normal contacts of the L2 relay instead of a single normal contact, so that if the L2 relay operates to start the next selection while a select magnet and the SM relay are still locked, and two adjacent P relays are both momentarily operated, the locking ground for the operated select magnet can not find a path to operate another select magnet.

The operating circuit for the select magnets is taken through a normal contact of the SM relay so that if the P6 relay releases faster than the other operated P relay, momentarily closing an operating path to another select magnet, there will be no ground on that path.

The operating circuit for the select magnet is taken through a back contact of the TT relay so that when eleven pulses are counted for a telltale condition, no select magnet will operate, in order to save unnecessary wear on the switch.

OS- (22)

P1 to P6

The P1 to P6 relays have two possible locking circuits, one from the operated contacts of the L2 relay and one from the normal contacts of the SM relay. The one through the L2 relay is opened first by its release, but the P-relays remain locked to the SM relay until the selection is registered on the crossbar switch.

RA1 (21)

When the SM relay operated the first time to register the trunk link frame number, it operated the RA1 relay, and when it released, the RA2 relay also operated. When the SM relay operates the second time to register the office brush selection, it shunts the RA1 relay which releases, and then when the SM releases, the RA2 also releases. That completes one cycle of the RA1 and RA2 relays, and on subsequent selections it goes through the same cycle. The RA1 and RA2 relays are used to affect a closure to the next succeeding crossbar switch hold magnet, after the preceding one has been operated and locked in.

OS- (21)

OB HOLD MAGNET

When the OB hold magnet operates, it locks to the ON1 relay and transfers an operated contact of the RA1 relay to the OG hold magnet. It closes the crosspoints at the level of the operated select magnet and grounds one of the B0 to B4 leads to the marker connector.

The OB hold magnet operates the OB relay for the purpose of affecting the timing circuit as explained later.

OFFICE GROUP SELECTION AND REGISTRATION

OS- (21)

SP

When the SM relay releases at the end of office brush registration, it removes the shunt ground from the STA relay to allow office group selection to take place. Office group selection is carried out in the same manner as office brush for counting pulses and registering the selection in the crossbar switch.

When the L relay releases at the end of office group selection, it immediately operates the SP relay, which locks to off-normal ground. The purpose of operating the SP relay is to open the fundamental circuit in the tandem sender preventing incoming trunk test from taking place when the originating sender is ready. This is done to allow time for the tandem marker to decode the office brush and office group selection and in turn notify the tandem sender whether the call is going to continue mechanically or terminate by P.C.I. pulses.

When the SP relay operates it opens the tip lead from the L relay and connects it to ground at the operated contacts of the RV3 relay. The ring lead is then grounded by the release of the L1 and L2 relays. The grounding of the T and R leads toward the originating sender serves to discharge the cable as well as preventing the originating sender from making incoming trunk test, until the marker determines the type of call.

TANDEM MARKER CONNECTOR CIRCUIT

OS- (23-1)

DST

Each sender circuit is wired to a tandem marker connector circuit by 42 individual leads. The function of the connector circuit is to connect the sender to a marker, which in turn receives the office code, the below or above fifty indication and trunk link frame information from the sender, returns the decoded information which the sender requires, and closes an outgoing path through the trunk link and office link frames.

When the OG relay operates at the end of office group registration, the DST relay operates to call in the tandem marker connector by connecting battery to the CBS and ST leads.

INFORMATION FROM SENDER TO MARKER

OS- (24)

Connection of battery to the ST lead to the connector circuit causes it to connect the sender to a tandem marker. The sender transfers to the marker the number of the trunk link frame involved, by means of leads F0, F1, F2, F3, F4 and FB5 or FA5, the two digits of the office code by means of leads B0, B1, B2, B3, B4 and G0, G1, G2, G4 and GB5 or GA5 respectively. Also the grounding of lead BB5 or BA5 and F00 or F10.

Leads TR1, TR2 and OF are used to indicate to the marker first, second or third trials respectively.

The following is the combination of leads grounded for the frame identification, office brush and office group registration.

Frame (FR)	Leads Grounded
0 or 10	FB5 - F0
1 or 11	FB5 - F1
2 or 12	FB5 - F2
3 or 13	FB5 - F3
4 or 14	FB5 - F4
5 or 15	FA5 - F0
6 or 16	FA5 - F1
7 or 17	FA5 - F2
8 or 18	FA5 - F3
9 or 19	FA5 - F4

Office Brush	Grounded Leads
0	B0
1	B1
2	B2
3	B3
4	B4

Office Group	Grounded Leads
0	GB5 G0
1	GB5 G1
2	GB5 G2
3	GB5 G3
4	GB5 G4
5	GA5 G0
6	GA5 G1
7	GA5 G2
8	GA5 G3
9	GA5 G4

The code group lead BB5 or BA5 is grounded through the office brush crosspoints on the OB vertical of the crossbar switch.

The F00 or F10 is grounded from the F00 or F10 relay.

The TR1 lead is grounded by the ON2 relay indicating a first trial.

INFORMATION FROM MARKER TO SENDER

The marker transmits the required information to the sender by grounding a selection of leads to operate the correspondingly designated selection register relays in the sender. These relays may be released and reoperated in a different pattern if the marker should be unable to find an idle trunk and an idle path to it on the routing. The sender relays operated at this time are given in the following, as applying to all classes of calls:

Class of Call	Leads Grounded	Relays Operated
Panel	None	None
Crossbar	XB	XB
Call Indicator	CI	CI
Vacant Code	XB & OD	XB & OD
Overflow	None	None

Compensating Resistance	Trunk Guard Relay	Leads Grounded	Relays Operated
0	TG	None	None
0	MTG	CR5	CR5
300	TG	CR1	CR1
300	MTG	CR1 & CR5	CR1 & CR5
600	TG	CR2	CR2
600	MTG	CR2 & CR5	CR2 & CR5
900	TG	CR1 & CR2	CR1 & CR2
900	MTG	CR1, CR2 & CR5	CR1, CR2 & CR5

The CR5 relay is operated on all calls over trunk groups containing some trunks to non-repeating ground cut-off panel incoming selectors. It serves to substitute relay MTG for TG to close a cable discharge circuit before final brush selection and to close a path which insures operation of the O, BO, and FO relays in case a very short reversed battery pulse is received in incoming advance.

SELECTION OF TANDEM TRUNK BY MARKER

OS- (22)

DC

After the marker has operated the required register relays, it proceeds to select an idle trunk to the called office. After having selected the idle trunk, the decoder connects ground to the DC lead through the connector to the tandem sender to operate the DC relay. After the DC relay closes its contacts, this same ground is extended to the DC crosspoints of the sender link to the tandem trunk operating the F relay. The F relay in closing its contacts extends this same ground to the LC lead which operates and LC relay which causes the trunk to be connected to the trunk link frame, where again this same ground is extended to the marker operating the AK relay. When the marker AK relay operates it locks and extends locking ground back through the trunk link frame and tandem trunk to the tandem sender locking the LC, F and DC relays in preparation of releasing the marker connector.

OS- (22)

STB

Whenever the tandem sender DC relay is operated, it sends a current through the winding of the STB relay to soak it in the direction of its normal operation and so removes the residual effect of any proceeding reverse current. The battery and ground for this soak is supplied from the contacts of the DC relay which operates the STB relay.

RELEASE OF MARKER CONNECTOR

OS- (24)

DRL

When the marker has sent its selection information to the sender; operated the DC relay and locked it in through the trunk link frame, it grounds lead RL through the marker connector to operate the sender DRL relay.

The DRL relay locks in the selection information supplied to the sender and opens the battery to the ST leads to release the marker connector.

On release of the connector, the marker is then in indirect communication with the sender through the sender link and the tandem trunk.

CONNECTION ESTABLISHED
MARKER RELEASES

OS- (22)

DC

When the marker has completed its work of establishing a connection from the calling trunk through the trunk link and office link frames to the trunk of the distant office, it removes ground from the DC lead releasing the F relay of the tandem trunk and the DC relay of the tandem sender. This is a signal to the tandem sender to proceed with its work.

The release of the DC relay removes the soak and releases the STB relay in preparation for terminating incoming brush selection.

PROGRESS OF THE SELECTION SEQUENCE

OS- (23-1)

S6 & S6'

The selection relays S-1 and S-1' to S-6 and S-6' and relays FS1 and FS2 are used to make the proper connections in the sender in a definite order as the sender progresses through its successive terminating selections and trunk test. On a full selector call to panel or crossbar these relays are operated as follows for the several stages:

Stage of Call	Relays Operated
Trunk Test	S6, S6'
Incoming Brush Selection	S1, S1', FS1
Incoming Group Selection	S2, S2', FS1
Final Brush Selection	S3, S3', FS1
Final Tens Selection	S4, S4', FS1, FS2
Final Units Selection	S5, S5', FS1, FS2
Incoming Advance	S6, S6', FS1, FS2

The S6 relay operated from the operation of the DRL relay and upon the closure of its contacts, puts a short circuit on the S6' relay. When the DC relay releases, the short-circuit is removed and the S6' relay operates. The S6' relay when operated connects the 14,500 ohm AP resistance in preparation for terminating trunk test to prevent the incoming trunk L relay from operating.

FULL SELECTOR CLASSES OF CALL

OS- (21)

RV

There are two full selector classes, one to panel offices in which case there are no class relays operated and one to crossbar offices in which case the XB relay is operated. This tandem sender is arranged to control existing panel selectors in the same manner as a panel subscribers sender controls them and to transfer the number to crossbar terminating equipment using the same means.

On a call to a crossbar office, the terminating sender replaces the functions of the panel incoming and final selectors in supplying the battery and ground required for trunk test, sending revertive ground pulses to satisfy the tandem sender and provides the reversed battery signal after selections are completed. In sending the revertive ground pulses, the terminating sender records the called line number in terms of incoming and final selections.

On a full selector call to a panel office, that is with the XB relay released, the slow release FO1 relay serves to extend the time of terminating trunk test and certain terminating selection. On a call to a crossbar office, the operation of the XB relay eliminates the use of the FO1 relay because extra long times between selections are not required. With these exceptions the two classes are treated exactly alike.

When the S6' relay operates for a call, except on a P.C.I. call when the CI relay is operated, it operates the RV relay for the purpose of allowing the originating sender to continue with the incoming and final selections.

OS- (22)

L

The operation of the RV relay closes through the fundamental from the originating sender which was previously opened by the operation of the SP relay. With this closure the originating sender makes incoming trunk test from battery through the winding of the L relay in parallel with the BN resistance battery on the normal contacts of the L1 relay and ground on the normal contacts of the L1 and L2 relays and the operated contacts of the SM relay. The BN resistance battery on the L1 relay serves to have the L relay meet its non-operate test during the originating sender incoming trunk test.

The originating sender completing its trunk test moves into incoming brush selection at which time the tandem sender L relay operates.

ORIGINATING SENDER INCOMING AND FINAL SELECTION

OS- (22)

STA

When the L relay operates for originating sender incoming brush selection, it operates the L1 and L2 relays which causes the SM relay and select magnet that is still operated from office group registration to release.

When the SM relay releases it removes the last shunting ground from the STA relay which operates and starts pulsing for incoming and final selections as previously described for office brush and office group selections. Each one of these five selections cause relays L to L-5, RA1, RA2 and P-1 to P-6 to operate and release as described for office brush selection.

INCOMING AND FINAL REGISTRATIONS

OS- (21)

The incoming and final selections are registered the same as already described for office brush registration. The RA1 and RA2 relays perform their functions to transfer each succeeding registration to its proper vertical operating the IB, IG, FB, FT and FU hold magnets.

TERMINATING INCOMING TRUNK TEST

OS- (22)

TG or MTG

When the marker signalled the tandem sender for connector release, the DRL relay was operated in turn operating the S6, FO1, and FO2 relays. The FO1 relay was operated through the normal contacts of the IG hold magnet of the crossbar switch. The purpose of putting the release of the FO1 relay under control of the IG hold magnet is to prevent the incoming selections at the terminating office from taking place until the incoming group selections from the originating sender are registered on the crossbar switch.

After the operation of the IG hold magnet the FO1 relay releases, followed by the release of the FO2 and operation of the RC and FO3 relays. The FO3 relay operated, closes the fundamental FT and FR leads to the terminating office for incoming trunk test, operating the TG or MTG relay. The fundamental circuit is traced as follows: battery from distant L relay over FT lead, make contacts RV relay, break contacts RR and AV2 relays, make contacts SG relay, break contacts FS1 relay, winding of TG or MTG relay and make or break of CR5 relay respectively, through 14,500 ohm resistance, make contacts S6' relay, break contacts FO2 relay, make contacts FO3 relay, make or break contacts CR2 and CR1 relays, make contacts RV relay, FR lead to distant office ground.

The TG or MTG relay is used for terminating incoming trunk test to determine that a normal trunk has been selected which is in condition for use. The FT and FR leads are closed at this time through the sender link, tandem trunk, trunk link frame and office link frame to the outgoing trunk to the panel incoming selector or a crossbar trunk circuit. The battery and ground to operate the TG or MTG relay are furnished at the tip and ring, respectively, the battery being applied through the winding of the distant circuit L or A relay. The 14,500 ohm resistance in the circuit prevents the distant circuit L or A relay from operating and permits the TG or MTG relay to operate only on 48 volt battery, thus preventing its operation if a trunk in talking position has been selected, due to a trouble.

The CR5 relay, operated or left normal by the decoder, determines which trunk guard relay is used. Either one may be used for office test, the requirement being based on the incoming trunk group through which the call is to be routed. If the incoming trunk group includes any trunks to non-repeating ground cut-off incoming selectors, the decoder will have operated the CR5 relay and the MTG relay will be used. Otherwise the CR5 relay will be normal and the TG relay will be used.

The path for operating the TG or MTG relay is traced through contacts of the CR1 and CR2 selection register relays, operated or left normal by the decoder and through sufficient resistance to increase the trunk resistance to a minimum of 900 ohms. The fundamental circuits for incoming and final selections and incoming advance also include this resistance.

The operation of the TG or MTG relay operates the TG1 relay, which operates the zero, BO and FO counting relays, and then awaits the opening of the fundamental by the operation of the FO2 relay which releases the TG or MTG relay.

OS- (23-1)

S1 & S1'

The operation of the FO relay operates the S1 relay which locks. The S1' relay is short-circuited while the FO relay is operated. When the FO relay releases, the short-circuit is removed from the S1' relay which operates in series with the S1 relay. The S1' relay in operating releases the S6 and S6' relays and operates the FS1 relay.

TERMINATING INCOMING BRUSH SELECTION

OS- (22)

STB

When the S6' relay releases, the FO2 relay releases followed by the operation of the RC and FO3 relays. When the FO3 relay operates, the fundamental is again closed but through a different path including the STB and OF relays but minus the 14,500 ohms resistance for terminating incoming brush selection. The path is traced as follows: battery FT lead, make contacts RV relay, break contact FR and AV2 relays, winding of OF and STB relays, break contacts BO relay make contacts FB1 relay, break contacts FO2 relay, make contacts FO3 relay, make or break contacts CR2 and CR1 relays, make contacts RV relay to FR lead ground. The STB relay operates in this circuit and in series with the L or A relay in the distant office.

The primary and tertiary windings of the OF relay, in parallel, are included in this path and in all other fundamental circuits for selections but the relay does not operate as it is polarized and the current flow through the primary winding is not in its operate direction. The tertiary winding is non-inductive.

When selections start on a call to a crossbar office the battery and ground for the fundamental is furnished from a terminating sender.

The incoming brush selection is controlled by the crosspoints closed on the IB vertical of the crossbar switch. The path to operate the counting relay at which the count starts is traced from ground at the FS2 relay normal, operated contacts of the STB relay, normal contacts FS2 relay, normal contacts 6' relay, normal contacts 1' relay, operated contacts S1' relay, crosspoints of IB vertical and over a numbered lead to the counting relay pair required, which corresponds in number to the required incoming brush. All leads on the print terminating in circles of like numerical designation are connected together.

Operation of the incoming L relay advances the incoming circuit for making brush selection, ground pulses being impressed on the FT lead by the A commutator. These ground pulses alternately shunt the STB relay and permit it to reoperate, thus causing the prime counting relay associated with the relay previously operated and the lower numbered pairs to operate in order. The counting relays look in series with their prime relays.

The number of impulses received is equal to the number of counting relay pairs included in the selection which in this case is 1 to 5 pulses and is always one greater than the number of the counting relay at which the count starts. When the last ground pulse is received, shunting the STB relay, the BO and FO relays operate in parallel. The BO relay opens the fundamental circuit, preventing reoperation of the STB relay, and the FO relay causes the advance of the tandem sender.

OS-(23-1)

FO1, FO2 & FO3

When the FO counting relay operates, it operates the S2 relay, followed by the FO1 and FO2 relay, depending upon whether the call is terminating in a panel or crossbar office. If the XB relay is released indicating a panel termination the FO1 relay operates, but if the XB relay is operated indicating a crossbar termination the circuit for the FO1 relay is open and a path is closed to operate the FO2 relay. When the FO1 relay operates, it will operate the FO2 relay.

The FO2 and FO3 relays make additional breaks in the fundamental, anticipating the release of the BO relay which recloses the fundamental at its contacts.

TERMINATING INCOMING GROUP SELECTIONS

OS- (23-1)

S2 & S2'

With the S2' relay operated, the S1 and S1' relays release, followed by the release of the FO1 and FO2 relays or just the FO2 relay this depending upon the XB relay being operated or released.

The slow release FO1 relay is used to increase the open period between fundamental closures by approximately .065 seconds, making the total open period, from operation of the BO relay to operation of the FO3 relay, approximately .130 seconds. This feature is necessary only in certain selections involving panel selectors, and not in any case in connection with crossbar terminating equipment.

This long delay is required, to permit a panel selector to advance, in any No. 0 selection which starts with the selector commutator already closed. This condition exists when the incoming and final frames with a combination of No. 4 brush and No. 0 group or tens is used at the terminating office. In these cases, the B commutator is left closed when brush selection is completed.

Closure of the fundamental for group or tens selection operates the L and STB relays and when the L relay contact closes the STP relay is immediately shunted, satisfying the sender. After that, the selector circuit has to raise its brush rod, breaking the commutator releasing the L relay to advance its switch, before it can be set for the next selection. A similar condition is encountered in final units selection on a call in which the units digit is zero.

In order to allow sufficient time for the selector to advance before the sender again closes the fundamental and thus prevent out of step conditions due to the above, the slow release FO1 relay is employed in all cases after office group selection and on panel calls, as described later after incoming group, final tens and final units selections.

When the FO3 relay operates, the fundamental is again closed for incoming group selection, 1 to 4 ground pulses being impressed on the FT lead. Incoming group selection is controlled by the IG vertical of the crossbar switch, the counting relay path being closed through by the S2' relay operated.

The terminating equipment advances and returns ground pulses, causing the STP relay and the counting relays to function as before. The BO relay opens the fundamental circuit and the FO relay causes the following:

SYNCHRONIZING SELECTIONS

OS- (23-1, 23-2)

It is the function of this tandem sender to receive the incoming and final selections from the originating sender and upon their registration on the crossbar switch immediately to send them out to the terminating equipment. The reception and sending out of a selection is synchronized by the off-normal contacts of the FB, FT and FU hold magnets and the FO1 and FO2 relays.

Since it is necessary to have the IG hold magnet operated before any terminating selections can start, there is no synchronizing necessary on incoming brush and group selections. After terminating incoming group selection is completed it is necessary that the originating final brush selections be registered, in order for terminating final brush selections to take place. This is accomplished by holding operated the FO1 or FO2 relay through the released contacts of the FB hold magnet and the operated contacts of the S3 relay, until the FB hold magnet is operated. When the S2' relay releases the FO1 or FO2 relay will release if the originating final brush selection has been received. This condition also applies to the terminating final tens and final units selection.

TERMINATING FINAL BRUSH SELECTION

OS- (23-1)

FO3

As previously described, the CR5 relay is operated if the group includes any trunks to non-repeating ground cut-off panel incoming selectors. If it is operated, the release of the F03 relay connects 25,500 ohms resistance across the FT and FR leads to discharge the trunk cable. This is done to avoid danger of a false pulse through the STB relay due to connection of the final circuit L relay to the fundamental.

OS- (23-1)

S3 & S3'

When the S3' relay operates, the S2 and S2' relays release, followed by the release of the F01 or F02 relay if the originating final brush selection is registered. When the F03 relay operates the fundamental is closed for selections 1 to 5 ground pulses being impressed on the FT lead.

Final brush selection is controlled by the FB vertical of the crossbar switch, the counting relay path being closed through it by the S3' relay operated.

The terminating equipment advances and returns ground pulses, causing the STB relay and the counting relays to function as before.

OS- (23-1)

FS2

The FS2 relay reverses the direction of current through the contacts of the STB relay to give longer life to these contacts. When the S4 relay operates on a panel call the F01 relay operates before the F02 relay. This is due to the released XB relay.

F01 or F02

The F02 relay releases only if the originating final tens selection has been received on crossbar to crossbar calls. On calls from crossbar to panel the F01 relay releases if the originating final tens selection has been received. Otherwise, terminating final tens selection is delayed by a path which holds the F02 or F01 relay operated through normal contacts of the FT hold magnet.

TERMINATING FINAL TENS SELECTIONS

OS- (23-1)

S4 & S4'

Final tens selection is made with the S4 and S4' relays operated, starting when the F03 relay operates to close the fundamental. The pulses impressed on the FT lead may be from 1 to 10 pulses. Final tens selection is controlled by the FT vertical of the crossbar switch, the counting relay path being closed through it by the S4' relay operated.

The terminating equipment advances and returns ground pulses, causing the STB relay and the counting relays to function as before.

In the final selector frame there are ten groups in a bank. If group No. 5 or over is to be selected, the counting relays are split by the 5 to 9 crosspoints of the FT vertical in the crossbar switch. In this case the count starts at the relay pair numbered 5 less than the group desired, except for No. 5 group, the count for which starts at the No. 6 relays, using No. 0 lead. The counting relays, when split, are connected to operate in the following order: 4, 3, 2, 1, 6, 5, 4, 3, 2 and 0. To accomplish this, the RC relay releases when the No. 5 relay operates and the No. 4, 3 and 2 pairs, operated on the first cycle, release when the No. 6 relay operates so that they may be used a second time. Also, when any of the crosspoints 5 to 9 in the FT vertical are closed, they connect No. 1 pair to No. 6 pair instead of to No. 0 relays, to give the above sequence, and the RC relay normal on the second cycle connects No. 2 pair to the No. 0 relays.

When any crosspoint 0 to 4 of the FT vertical are closed the No. 1 relays are connected to the No. 0 relays and no splitting is required.

When the last ground pulse is received, shunting the STP relay the BO and FO relays operate in parallel. The BO relay opens the fundamental circuit, preventing reoperation of the STP relay, and the FO relay causes the tandem sender to advance for the next selection.

TERMINATING FINAL UNITS SELECTION

OS- (23-1)

S5 & S5'

Final units selection is made with the S5 and S5' relays operated, starting when the FO3 relay operates to close the fundamental. The pulses impressed on the FT lead may be from 1 to 10 pulses.

Final units selection is controlled by the FU vertical of the crossbar switch, the counting relay path being closed through it by the S5' relay operated.

The terminating equipment advances and returns ground pulses, causing the STB relay and the counting relays to function as before. The counting relays may be split for this selection as described for final tens selection but controlled by the FU vertical. A second row of contacts on this vertical is used to connect the operated contact of the No. 1' relay to either the No. 0 relay or No. 6 pair as required.

The BO relay opens the fundamental circuit and the FO relay causes the tandem sender to advance for terminating incoming advance.

Originating sender registration having been completed, there is no delay at this point.

TERMINATING INCOMING ADVANCE

OS- (23-1)

S6 & S6'

Terminating incoming advance is made with relays S6 and S6' operated, starting when the FO3 relay operates to close the fundamental after the completion of final units selection.

The tandem sender is now in a position to receive battery on the FR lead and ground on the FT lead from the incoming circuit or terminating sender as a signal that all selections have been complete.

OS- (22)

OF

Closure of a single long pulse of reversed battery from the distant and of the outgoing trunk operates the OF and STB relays in series. The OF relay locks but the STB relay releases at the end of the pulse.

The OF relay operates the 1A and with both the STB and 1A relays operated, the O counting relay operates. When the STB relay releases, the BO and FO relays operate and lock in a series parallel circuit with the O counting relay.

OS- (23-1)

1A

Non-repeating ground cut-off panel incoming give so short a reversed battery pulse that the STB relay may not stay operated long enough after 1A operates to operate the O relay, so the above described method of operating BO and FO at the end of the pulse may fail. To insure the operation of BO and FO, the 1A relay closes a supplementary path through operated contacts of the CR5 relay to operate O, BO and FO simultaneously when the STB relay releases, in case the O relay was not operated before.

The supplementary path would cause BO and FO to operate too soon in case the 1A relay should close it before the STB relay operates. This is a possibility on long trunks which cause the STB relay to lag in operation behind the OF relay. It would cause the tandem sender to proceed without insuring the advance of the incoming and checking that it does advance. To prevent this, the supplementary path is carried through the CR5 relay operated, as described above, and is therefore ineffective on trunks not requiring it.

Operation of the BO relay at this time breaks the bridge across the fundamental in the tandem sender to prevent its giving a premature trunk closure.

When the incoming has cut-off the reversed battery it connects direct battery instead to the fundamental and awaits a trunk closure bridge before proceeding to ring the called station.

ORIGINATING SENDER INCOMING ADVANCE

OS- (3-1)

RB

When the last selection final units was transferred from the originating sender to the tandem sender, the T and R leads are opened, resulting in the release of the tandem sender L relay. When L releases the L1 and L2 relays release.

The originating sender after completing final units selection, closes the circuit again through its stepper and overflow relays to await a reverse battery pulse for incoming advance. The tandem sender L relay operates through this circuit and the originating sender STP relay but the OF relay remains normal since the battery is still in the normal direction. The originating sender STP relay performs no function when operated in this circuit. The L relay receives its operating ground from the crosspoints of the final units vertical on the crossbar switch. This same ground short-circuits the STA relay, preventing any further operation of this relay. The L relay then operates the L1 and L2 relays, the L locking independent of the SM relay.

When the FO relay operates on terminating incoming advance, it operates the RB relay through the front contacts of the IA and L2 relays: the RB relay operates starts the incoming advance feature toward the originating sender.

OS- (21)

RV1

The ground that was previously connected to the R lead by the FU hold magnet is still present. When the RV1 relay operates, this same ground is connected to the T lead during the transfer of top 1, 2 and 3 contacts and at the same time this ground holds the L relay operated. With both the T and R leads grounded on the transfer of these contacts, a cable discharge is started causing the originating stepper relay to lose its energy and the L relay to be heavily energized.

After the RV1 relay is fully operated the L relay has been transferred to the R lead but is still being held operated by the ground from the FU vertical crosspoints, since the discharge circuit is still in progress. The operated RV3 relay maintains ground on the T lead.

OS- (21)

RV2

The RV2 relay is slow operate for the purpose of holding the cable discharge circuit sufficiently long to be effective. When the RV2 relay opens its bottom 1 and 2 contacts the discharge circuit is opened and the reversed battery becomes effective in the originating sender, operating the OF relay.

The reversed current goes out suddenly on account of the heavily soaked condition of the L relay. The purpose of this procedure is to compensate for a tendency under certain conditions for the overflow relay to operate faster than its associated stepper.

OS- (21)

RV3

When the slow release RV3 relay releases it breaks the connections to the T and R leads, terminating the reverse battery pulse and allowing the originating sender stepper to release. The tandem sender L, L1 and L2 relays also release at this time.

TRUNK CLOSURE TO TERMINATING OFFICE

OS- (21)

RV6

When the RV6 relay operates it connects a ground through the winding of the TC relay to the D lead, which extends through the sender link crosspoints to the tandem trunk operating the D relay. This is a low resistance ground since the TC winding is 2 ohms. The TC relay does not operate at this time because it is polarized and operates only when the current has a positive polarity applied from the trunk toward the tandem sender.

The tandem trunk D relay in operating cuts in the supervision toward the distant office and returns a ground on the DC lead to the tandem sender as a check that this operation has been completed.

OS- (21)

RV7

When the RV7 relay operates, it connects resistance battery to the T lead and ground to the ring lead for discharging the cable from the preceding reverse battery pulse to prevent false operation of the trunk A relay when trunk closure is attempted.

OS- (22)

CK1

The operating circuit of the CK1 relay checks to see that ground was applied to the DC lead from the trunk and that the RV7 relay operated to discharge the cable.

TRUNK CLOSURE TO ORIGINATING OFFICE

OS- (22)

CK2

The CK2 relay disconnects the resistance battery and ground from the T and R leads completing the discharge of the cable.

The operation of the CK2 relay opens the CO lead toward the tandem trunk which causes the trunk T relay to release. The release of the T relay connects the trunk A relay to the T and R toward the originating office for trunk closure.

OS- (22)

CK3

If the trunk T relay has released satisfactorily, it removes the ground from the DC lead releasing the CK1 relay, which in turn operates the CK3 relay.

TRUNK CLOSURE COMPLETED

OS-(22)

TC

After reverse battery for originating incoming advance is accepted by the originating sender, it proceeds to make a zero talking selection, advancing the panel district to its required position. Upon closure of the panel district repeat coil to the T and R leads the tandem trunk A relay operate. In this circuit is included the panel district polarized CS relay which does not operate at this time, due to the current being in the wrong direction.

The tandem trunk A relay in operating locks in the D relay and at the same time is connecting positive polarity to the D lead toward the tandem sender, operating the TC relay. Therefore, the operation of the TC relay is an indication that trunk closure was completed.

TANDEM SENDER RELEASE

OS-(22)

RL

When the TC relay operates, it operates the RL relay for releasing the sender. The RL relay locks under control of the ON2 relay and breaks the local ground connection which releases the ON1 relay. It also removes ground from the sender link S lead, releasing the link hold magnets, freeing the sender from its external connections.

OS- (21)

ON1

When the RL relay operates, the ON1 relay releases and starts a chain of releases, at the same time the RV6 and RV7 relays release, opening the TM4 timing which was checking for trunk closure.

OS- (21)

ON2

The release of the ON2 relay opens the TM2 interrupter and the timing for the release of the sender.

OS- (25-2)

SB LEAD

When the RL relay releases, ground is removed from the SB lead, which allows the SB relay to release in the sender subgroup circuit, putting the sender back in preference.

OPERATOR STRAIGHTFORWARD CLASS CALL OS(24)

A straightforward class call is indicated when the marker operates the (CI) and (OD) relays. The fundamental is exactly the same as for a PCI call as described in paragraph 15.01 except that (OD1) which operates from (OD) connects "T" and "R" to battery and ground respectively. For this class of call when the originating sender closes the circuit for trunk test, relays (S) and (SA1) operate. Then the originating sender opens "T" and "R" and (S) releases followed by the operation of (SA3) which locks and connects the front contact of (S) to (SA4). The originating sender then closes "T" and "R" reoperating (S) which operates (SA4). (SA4) locks and operates (PA1), (PA2), and (PA4) in series. (PA4) operated opens "T" and "R" and (PA2) releases (PA3) and that operates (RV6) as for a PCI call. (RV6) closes ground to the "D" lead in the trunk. The sender (CK1), (CK2) and (CK3) operate as described for sender release. When the trunk (A) relay operates it will operate (TC) and the sender will be dismissed in the usual manner.

Completion of operator direct class originally anticipated by the use of Fig. C has been abandoned and since this class has never been used Fig. C is rated "Mfr. Disc.". Therefore the description of operation for this class is not given.

OUT DIAL PULSE CALL OS (24)

This section describes all of the operations on a completed out D.P. call which are peculiar to that class of call. There are three out D.P. classes; a four digit class, a five digit class, and a six digit class which is optional. These classes are all distinguished from any other class by relay (SSA) or (SSB) or both being operated thereby operating (SS). In addition to (SS) either or both (SO) and (IG5) may be operated by the marker depending upon the number of digits to be out-pulsed. For a 4 digit call (SS) and (SO) operated cause trunk test to be made following marker release and the reception of incoming brush and group selections; for a 5 digit class (SS), (SO) and (IG5) operated cause trunk test to be made following marker release, followed by the transmission of the fifth digit, and then wait the registration of incoming brush and group before proceeding; for a 6 digit class (SS) operated causes trunk test to be made following marker release, followed by the transmission of the 5th and 6th digits, and then wait the registration of incoming brush and group before proceeding. The operation of (SS) causes the operation of (SS1), (SS2), (SS3), (SS4), (SS5) and (SS6). These relays make the necessary connections for the transmission of out dial pulses and are otherwise used for completing this class of call.

FUNDAMENTAL CIRCUIT OS (22)

During trunk test the fundamental is closed from the "FT" lead through back contact of (OD1), front contact of (RV), back contacts of (RR) and (AV2), front of (S6), back of (FS1), the winding of (TG), 7000 ohm resistance, front of (SS), 14,500 ohm resistance, front of (S6') back of (FO2) front of (FO3), back or front contacts of (CR1) and (CR2) and front contact of (RV), back contact of (OD1) to the "FR" lead.

During loop pulsing "A" with (SSA) operated the fundamental is closed from the "FT" lead through back contact of (OD1), front contact of (RV), back contacts of (RR) and (AV2), the operating winding of (OF) shunted by its noninductive winding, front contacts of (FS1) and (SS1), back of (LR), back contacts of (SAB), front of (PLS), back of (SAB) and (SSB), back of (SAB), front of (RV) back of (OD1) to the "FR" lead.

During loop pulsing "B" with (SSB) operated the fundamental is closed as described for loop pulsing "A" except that (SSB) introduces a 1481-ohm resistance into the pulsing circuit and also provides a different protective network, consisting of U resistance and condenser, for the contacts of the (PLS) relay.

During Battery and Ground Pulsing with (SSA), (SSB) and (SAB) operated the fundamental is closed as described for loop pulsing "A" except that (SAB) disconnects the (PLS) relay contacts from the fundamental and connects them to the winding of the (OPA) relay. (SAB) also connects the front contacts of (OPA) to the fundamental through the contacts of (OPC) and resistance (AB).

The purpose of the 21,500 ohm resistance in trunk test is to prevent the line relay of the selector or repeater from operating until the pulsing contacts of (PLS) or (OPA) are in circuit and the sender is otherwise ready to transmit pulses.

TRUNK TEST OS (22)

The fundamental is closed when relays (S6') and (FO3) are operated and (TTD)OS(23-1) released. (TTD) operates upon the operation of (DC) and (DRL) when the marker establishes connection to a trunk; (S6) operates following (TTD) and (S6') operates following the release of (DC) and (TTD). Slow to release relay (TTD) is used to delay closing of the fundamental, except on sender only class, in order to prevent seizing out D.P. equipment off-normal from a previous connection.

4-Digit Class - When the registration proceeds far enough to operate the (IG) hold magnet.

5-Digit Class - When the sender receives a marker release.

6-Digit Class - When the sender receives a marker release.

(TG) is used for all out D.P. classes. If the code is for a 5 or 6-digit class (CR5) may be operated as a 5th digit indication but the (MTG) is not cut into the fundamental as its path is opened at (SS). The (TG) operates from battery and ground from the outgoing repeater circuit or selector.

The operation of (TG) operates (TG1), (TG1) operates (O), (BO), and (FO). The (FO) operates (S2), (S1) or (S7) depending whether the call is 4, 5 or 6-digit class respectively. Any one of these relays operated operates (FO2), which releases (FO3) and (FO8). The release of (FO3) breaks the fundamental releasing (TG1) and (FO8) opens the locking circuit for (O), (BO) and (FO). Therefore all the (TG) and counting relays release.
OS (23-1)
The release of (FO) allows the (S1'), the (S2') or (S7') to operate in series with its associated counter relay and they lock. Any one of the prime relays opens the locking circuit for (S6), (S6') and they release. (S6') releasing, releases (FO2) and then (RC), (FO3) and (FO8) operate for pulsing the first digit.

The operation of (S1'), (S2') or (S7') also operates (FS1) which makes the proper connections for pulsing.

GENERATION OF OUT DIAL PULSES OS(23-1)

The out dial pulsing circuit consists of start interrupter relay (SSP) pulse generating relay (PG) pulsing relay (PLS) and check relay (CK). (PG) is a non-biased condenser timed relay. In series with its primary winding are connected relay (CK) and (PLS) which operate and release with (PG). Relay (PLS) and sometimes with (OPA) furnishes out dial pulses, and relay (CK) together with other relays counts the pulses. When (SS) operates ground is connected to the windings of (PG) and its associated network, to prepare the circuit for dialing. (PLS) and (CK) will operate but the current through (PG) is in a direction to cause its armature to move to its back contact. When relay (SSP) operates to start pulsing, ground is removed from the windings of (PG) and its associated network and this causes relays (PLS) and (CK) to release and after a timed interval (PG), (CK) and (PLS) will reoperate. These relays will then release and operate in unison at time intervals as controlled by the timed network. When sufficient pulses have been sent (SSP) releases thereby preventing (PG) from reoperating after the last pulse and also holding (PLS) and (CK) operated until the circuit is ready to transmit the next digit.

The pulse generating circuit is arranged to provide two sets of timed intervals; one for loop pulsing and the other for battery and ground pulsing. With (SAB) normal the resistance network is such as to provide one set of timed intervals for loop pulsing and when (SAB) is operated a different resistance network is connected into the circuit to provide the proper set of timed intervals for battery and ground pulsing. Since (SAB) is controlled by the marker the proper intervals are provided as required for the particular routing of the call.

PREPARATION OF CIRCUIT TO TRANSMIT PULSES OS(23-1)

Following trunk test when the fundamental is closed by (PLS) for loop pulsing a time interval is provided to soak the out trunk repeater relays before the start of pulsing. This time interval is obtained by allowing the pulsing relays to go through one pulse cycle before opening the fundamental for the first pulse. When (FS1) operated following trunk test the ground shunting (SSP) is removed allowing (SSP) to operate. (SSP) operated starts the pulsing and connects a ground to the winding of (F06) which is shunted by a ground from (CK). When (CK) and (PLS) release to start pulsing (CK) removes the shunt from (F06) and it operates and locks and when (CK) reoperates (F07) operates and locks. The release of (PLS) does not transmit a pulse since its contacts are shorted by back contacts of (F07). When the latter relay operates this short is removed and when the (PLS) relay again releases a pulse will be transmitted to the outgoing trunk repeater circuit. (F07) operated also closes a circuit from the back contact of (CK) to the counting relays for the purpose of counting the pulses.

When (SAB) is operated indicating battery and ground pulsing (PLS) does not close the fundamental as for loop pulsing but operates (OPA). The first release of (OPA) operates (OPC) which is slow to release and holds during the train of pulses. (OPC) removes the bridge from the fundamental and connects battery and ground thereto. At the end of each pulse train (OPC) releases thereby removing battery and ground from the fundamental and restoring the bridge thereto. (OPC) also short circuits (OF).

For the loop pulsing class "A" (SSA operated) resistance (DC) is introduced into the fundamental following each train of pulses. This is necessary to prevent a possible singing condition of a voice repeater in route, particularly when the loop between the sender and repeater is comparatively short.

COUNTING OUT DIAL PULSES OS(23-1)

When (PLS) and (CK) release to transmit the first pulse following the operation of (FO7), a circuit is closed from the back contact of (CK), front of (FO7) and (SS1) to the counting relays. These relays are counted up in the usual manner and when the correct number of pulses have been transmitted the operation of (CK) on the last pulse will cause the operation of (BO), (FO). (FO) operated releases (SSP) to stop pulsing and also operates (FO4) in a circuit from ground at front contact of (FO) front contact of (SS1), back of (S6) and (S5) to the winding of (FO4). (FO4) operated locks and operates (FO2) which in turn releases (RC) and (FO3). (FO3) released releases (FO8) and all counting relays except (Q), (BO), and (FO) and (FO8) released releases these. (FO) released removes the shunt from (FO5) and the latter operates. (FO5) operated releases (FO2) which reoperates (RC) followed by the operation of (FO3) and (FO8).

MEASURING THE INTERDIGITAL INTERVAL OS(23-1)

This interval which is approximately .6 second is measured from the end of the last pulse of a pulse train to the beginning of the first pulse of the succeeding pulse train and is obtained by using the interrupter circuit for counting 5 full pulses. The fundamental is held closed during this interval by a pair of contacts of (FO5) which shunts the pulsing contacts of (PLS). (FO5) operated disconnects the counting relays from the register circuit and connects them to the (4-4') pair of counting relays to count 5 pulses. The operation of (FO8) reoperates (SSP) to start the interrupter. When 5 pulses have been run through the (O), (BO),(FO) operate as previously described except that (FO) operated now shunts and releases (FO4). With (FO4) released and (FO5) operated one of the selection relays (S1), (S2), etc. depending on the selection to be made operates. This relay operated operates (FO2) which releases (RC) and (FO3) followed by (FO8) and (O), (BO) and (FO). (FO) released releases (FO5) which allows the corresponding selection relay (S1'), (S2'), etc. to operate in series with (S1), (S2), etc. relays respectively. This relay operated releases (FO2), if the following digit to be out dialed is registered, followed by the operation of (RC), (FO3), and (FO8). (FO8) operated operates (SSP) to start the interrupter for the succeeding pulse train. If the succeeding selection is not registered (FO2) is held operated by a back contact of the hold magnet corresponding to the selection to be made.

DECODING OF REVERTIVE REGISTRATION OS(23-2) (24)

Since the numericals are registered as Incoming Brush, Incoming Group, Final Brush, Final Tens and Final Units selections it is necessary to translate the first three of these into their corresponding thousand and hundreds settings for out dial pulsing. It is necessary also to change the connection to the counting relays for out dial pulsing since the latter is made on a decimal basis. The necessary switching for these translations is made by the (SS3), (SS4), (SS5) and (SS6) relays. No translation is necessary for the fifth or sixth digits, when used, as these digits are set up from the marker on the (CR) and (OG) relays in the proper manner for out dial pulsing.

The following table shows the thousands digit as translated from the Incoming Brush and Incoming Group selections; and the Hundred's digit as translated from the Incoming group and Final Brush selections.

Inc. Br. Registration	Inc. Grp. Registration	Corresponding Thousands Digit
0	0 or 5	0
0	1 or 6	0
0	2 or 7	1
0	3 or 8	1
1	0 or 5	2
1	1 or 6	2
1	2 or 7	3
1	3 or 8	3
2	0 or 5	4
2	1 or 6	4
2	2 or 7	5
2	3 or 8	5
3	0 or 5	6
3	1 or 6	6
3	2 or 7	7
3	3 or 8	7
4	0 or 5	8
4	1 or 6	8
4	2 or 7	9
4	3 or 8	9

Inc. Gr. Registration	Fin. Br. Registration	Corresponding Hundreds Digit
0 or 5	0	0
1 or 6	0	5
2 or 7	0	0
3 or 8	0	5
0 or 5	1	1
1 or 6	1	6
2 or 7	1	1
3 or 8	1	6
0 or 5	2	2
1 or 6	2	7
2 or 7	2	2
3 or 8	2	7
0 or 5	3	3
1 or 6	3	8
2 or 7	3	3
3 or 8	3	8

Inc. Gr. Registration	Fin. Br. Registration	Corresponding Hundreds Digit
0 or 5	4	4
1 or 6	4	9
2 or 7	4	4
3 or 8	4	9

The connections to the counting relays for out dial pulsing for all digits is as follows:

Digit	Counting Relay Connection
1	0
2	1
3	2
4	3
5	4
6	0
7	1
8	2
9	3
10	4

SYNCHRONIZING - OUT D.P. CLASS OS(23-1)

On all out D.P. classes it is necessary to hold up the pulsing of the thousands digit until incoming brush and group selections are registered; the hundreds digit must wait until final brush selection is registered. In areas where level hunting connectors are encountered it is necessary to delay the sending of the tens digit until the units digit is registered. This is to prevent the operator's answering following the pulsing of the tens digit and perhaps finding the talking path open at either the tandem or subscriber's sender. This delay is accomplished by the operation of the (WU) relay following the pulsing of the hundreds digit. (WU) operated prevents the (FO2) relay from releasing for the pulsing of the tens digit until the (U) hold magnet has been operated. It also serves to prevent the functioning of the (OF1) relay in case of a quick answer following the pulsing of the units digit.

A trunk test delay of approximately .3 second is provided for all out D.P. class calls. This time is provided by slow to release relay (TTD) which delays closing the fundamental for trunk test following marker release. Its intended purpose is to insure that step-by-step switches off-normal from a previous call will assume normal positions before trunk test is made. This is particularly necessary for 5 and 6 digit calls where trunk test is made as soon as marker release takes place, i.e., the sender does not have to wait for registration of Inc. Brush and Group selections before making trunk test.

On a 4-digit call trunk test is delayed until incoming brush and incoming group selections are registered. In this case the (FO1) relay is held operated, to prevent trunk test, until the (IG) hold magnet has been operated.

On a 5 or 6 digit call trunk test is made following marker release followed by the transmission of a fifth or a fifth and sixth digit after which the pulsing of the thousands digit is delayed until both incoming brush and incoming group selections have been registered. In this case (FO2) is held operated, to prevent further pulsing, until the (IG) hold magnet has been operated.

OUTPULSING FOR 6, 5 AND 4-DIGIT CALLS OS (23-1, 23-2) (24)

SIX DIGIT OUT D.P. CALL

For a six-digit call the marker operates the (SS) relay and following marker release trunk test is made followed by the operation of the (S7) and (S7') relays. The sixth digit, as set up on the (OG) relays by the marker, is outpulsed, the interdigital time is counted after which the (S1) and (S1') relays are operated for the transmission of the fifth digit which is set up on the (CR) relays by the marker. This digit is then outpulsed and the interdigital time is measured. When incoming brush and group are registered the thousands digit is outpulsed; the hundreds digit is pulsed with the (S3) and (S3') relays operated when final brush is registered; the tens digit is outpulsed with the (S4) and (S4') relays operated when final units is registered followed by the units digit with the (S5) and (S5') relays operated. The interdigital time is measured between all of these selections.

FIVE DIGIT OUT D.P. CALL

A five-digit call is indicated by the operation of (SS), (SO) and (IG5) from the marker. Following marker release trunk test is made followed by the operation of the (S1) and (S1') relays. The fifth digit, which is set up by the marker on the (CR) relays is then out-pulsed. From this point the operation of the sender is the same as described for a six-digit call.

FOUR DIGIT OUT D.P. CALL

A four-digit call is indicated by the operation of the (SO) and (SS) relays. In this case trunk test is not made until after marker release and the registration of both incoming brush and group selections. Following trunk test relays (S2) and (S2') are operated for the transmission of the thousands digit. From this point the operation of the sender is the same as described for a six-digit call.

STOP - START SIGNAL OS (22) (23-1)

For the sender only class of out dial pulsing, as indicated by (OB1) being operated from the marker, out pulsing is delayed until the distant sender indicates its readiness by sending reverse battery and ground over the FT and FR operating (OF) which in turn operates (ROF). Upon the termination of reverse battery, a path is closed from ground at back contacts of (OF), front of (ROF), front of either (S1'), (S2') or (S7') to operate (FS1) and start pulsing as previously described. A second reversal will function.

For the step-by-step switches only or step-by-step switches and a sender class of out dial pulsing, as indicated by (OB1) being unoperated, ground is closed from the back contact of (OF) to operate (FS1) and start out pulsing as soon as trunk test is completed. When it is desired to stop out pulsing after having dialed into one or two switches, in order to allow time for a distant sender link to select an idle sender, a reverse battery and ground signal is sent to this sender. (FO7) being operated and (OB1) unoperated, (SG) relay operates releasing (SSP) which stops any further pulsing at this time. When an idle terminating sender has been selected and is ready to accept dial pulses, the polarity of the FT and FR is restored to normal thus releasing (OF).

Ground is then closed from back contacts of (OF), through back contacts of (ROF), through front contacts of (FO7), through front contacts of (SG), operating (OB1). (OB1) operated closes a circuit to operate (SSP) and continue out pulsing as before.

The (OB1), (ROF), and (SG) relays, when operated, lock to the (DRL) relay to permit their release in case the (DRL) and (DST) relays are released for a second or third marker trial.

Should the trunk seized have its conductors reversed prior to the start of out pulsing or a reversal after the stop-start signal, this circuit will function as described in Paragraph 19.34.

COMPLETION OF OUT DIAL PULSING OS(23-1)

During the interdigital time preceding the pulsing of the units digit, with (FO5) released (S5) and (SSP) operated, a circuit is closed to operate (SDC) which locks. When the units digit has been transmitted (FO) operates and releases (SSP) to stop further pulsing, and closes a circuit through back contacts of (S6) front contact of (SDC) to front of (L2). When the latter relay is operated indicating that the fundamental is closed toward the originating sender (RB) operates and incoming advance is made as described for a revertive call.

During Incoming Advance and until the acceptance of trunk closure the step-by-step switches are held by the sender. When the incoming trunk line relay operates for trunk closure a holding bridge is provided by the originating end in multiple with the tandem senders bridge and at this time the sender will release and remove the sender bridge.

ALL TRUNKS BUSY AND VACANT CODES OS (24)

If all trunks are busy on first trials for regular or overflow trunks the marker will ground lead "RO" thereby operating (RO). If all trunks are busy on second trials, for regular or overflow trunks the marker will ground lead "TRL". If all overflow trunks are busy on third trial, which is an overflow trunk request, the marker will ground lead "TRL" causing the operation of (RO).

(RO) operated operates (DRL) to release the marker connector. (RO) also grounds a lead to the front contact of (CK3) so that when this latter relay operates, prior to sender release, the trunk hold relay will operate. (RO) also closes a circuit for operating both (SB) and (SB2). (SB2) grounds the incoming "T" lead, serving no useful purpose for the present discussion, and operates relay (SB1). (SB1) disconnects the (L) relay from the "T" lead together with its (BN) resistance shunt; closes a circuit for operating (RV4) when (RV2) operates; prepares a path from the front contact of (L) to operate (PA1); connects a ground to the back contact of (L); and prepares a path for reconnecting (L), shunted by resistances (BM) and (BP). Relay (SB) operated locks (RV3) to prevent terminating the ensuing reversed battery pulse; and causes the operation of relay (RB). (RB) operated locks and operates (RV1). (RV1) operates (RV2) followed by (RV4) and (RV5). (RV4) connects the (L) relay to the "R" lead shunted by resistances (BM) and (BP). (RV5) operates after a short interval following the operation of (RV4) and removes the BP shunt from the (L) relay. The object of applying the (L) relay to the ring shunted, as described is to prevent the false operation of the (L) relay when presented to the originating sender. The originating sender at this time may or may not have the fundamental closed for trunk test. If the fundamental is open the (L) relay must withstand the cable charging current as it is being applied to a discharged trunk. However, if the fundamental is closed and a high resistance test is presented the (L) relay again must not operate until the originating sender has advanced to the incoming brush selection position. Consequently the tandem sender (L) relay must withstand both the trunk test current and the cable charge current. The application of resistance shunt (BP) for a fraction of a second allows the cable to charge and at the same time provide a suitable shunt for the (L) relay. When this shunt is removed the (L) relay and the (BM) shunt will withstand the trunk test condition. When the originating sender advances to the incoming brush position, or if it is a P.C.I. class trunk test the (L) relay will operate and the originating sender will at the same time accept reversed battery. (L) operated operates relay (PA1) and when the originating sender opens the fundamental (L) releases allowing (PA2) to operate. (PA2) operated releases (PA3) and from this point the sender is released as described for a full selector call.

If a code is received by the marker which represents a vacant code it will operate a vacant code route relay and set the switches to a reorder trunk. Class relays (OD) and (XB) will be operated in the sender. These relays operated operate relay (SB1) and it functions as described in Paragraph 18.2. When marker release is effected a circuit is closed from ground at front contacts of (S6'), (XB) and (OD), back contact of (TMN), front of (OC) to the winding of (SB), (SB) operates and in turn operates (RB).

If the marker encounters trouble on a regular or vacant code routing and results in the sender's requesting an overflow routing on third trial the operation of (RR) will operate (SB2) and (SB1). The circuit will function as described when a marker release is obtained.

From this point reversed battery is applied and the sender functions as described,

OVERFLOW AND TELLTALE FROM TERMINATING EQUIPMENT

This section describes the action taken by the sender in case it receives an overflow indication, which is reversed battery coming in over the fundamental in any position of the sender except incoming advance on a full selector call. It may be occasioned by a panel type incoming or final selector running to overflow because of all trunks busy, or to telltale because of trouble, or by a crossbar terminating sender running to telltale or by a trunk to PCI a step-by-step selector, or operator having its conductors reversed. Briefly stated, the action of the sender for a panel or crossbar call is to put the offending selector or sender in the way of returning to normal, to restore the selection register and the selection sequence circuit to normal, and to call a marker to break down the connection forward and make another trial.

ACTION OF SELECTOR OR TERMINATING SENDER

The action of a panel selector or crossbar terminating sender when it runs to overflow or telltale connects reversed battery to the fundamental and recognizes a closure in the sender, then it connects direct battery to the fundamental and recognizes a second closure, commonly known as trunk closure, and then it returns to normal.

RECOGNITION BY SENDER OF REVERSED BATTERY OS (22)

If a panel incoming selector runs to overflow in hunting for a final selector or a terminating sender runs to telltale, the sender at that time will be in some selection position, with (STB) and (OF) in the fundamental. They will both operate on the reversed battery. (OF) locks up and it operates (OF1) through back contact of (S6'). (OF1) closes a circuit to operate (IA) and (O). When the distant selector or sender breaks off the reversed battery and releases (STB), (BO) and (FO) operate. The late closing front contact of (IA) serves to insure the operation of (O), (BO) and (FO) in the case of ground cut-off incoming selectors giving a very short pulse of reversed battery, as previously described.

On a PCI or operator class call if the trunk seized has its conductors reversed the originating sender as well as this sender will recognize this condition when the fundamental is closed for trunk test. (P) will operate followed by the operation of (PA1). When the fundamental is opened (P) releases followed by the operation of (PA2). The operation of (PA2) releases (PA3) and allows the operation of (RV6) and sender release is effected as previously described.

On an out D.P. class call if the trunk seized has its conductors reversed or premature reversed battery is applied to the trunk the sender will recognize this condition until the start of tens pulsing. (OF) will operate and lock and operate (OF1). (OF1) operated operates (SOF) which locks to (OF1).

The operation of the (OF) relay on out D.P. class to step-by-step switches only or to step-by-step switches and a sender stops the pulsing, as described in Paragraph 17.42. However, if the initial trunk connection from the tandem office multiple should be reversed, the operation of the (OF) relay, following trunk test, will operate the (OF1) relay, which operates (SOF) resulting in a second or third trial as described in Paragraph for Recall of Marker. On out D.P. classes in which no terminating sender is involved, a reverse battery encountered after the first step-by-step selection has been made will operate relay (SG) to stop further pulsing. If the reverse battery is continuous the sender will time out as described in Paragraph 21. If the reverse battery is momentary the pulsing will continue; but if it is intermittent, the second operation of (OF) will operate (OF1). resulting in a second or third trial.

The operating path for (OF1), on out D.P. classes to step-by-step switches is opened by the operation of (WU) which operates from (S4). No test for tip and ring polarity is therefore made between tens and units digits.

If the terminating sender, on out D.P. classes to step-by-step switches and a sender, should return reverse battery to the tandem sender after the release of (OF) following its operation as a stop-pulsing signal, then the second operation of (OF) will operate (OF1) and result in another trial.

On out D.P. to senders only class, the initial operation of (OF), by the sender associated with the outgoing tandem trunk, is required as a start pulsing signal. If the outgoing trunk is reversed the polarity of the sender signals will probably be reversed also. The (OF) relay will therefore operate twice. The second operation of (OF) will operate (OF1) through front contacts of (OB1), (FO7), and (ROF), resulting in a second or third trial.

If, on out D.P. to senders only class, the terminating sender should reverse its polarity, due to trouble or all trunks-busy conditions for example, at any time after the original start signal, the operation of (OF) will operate (OF1) through the path just mentioned. In this case the polarity test is not cancelled after the tens digit because the back contact of (WU) which opened the operating path of (OF1) on out D.P. class to switches is bridged by a front contact of (ROF) on out D.P. class to senders only. The operation of (OF1) will result in a second or third trial.

TRUNK CLOSURE FOR TERMINATING EQUIPMENT (PANEL AND CROSSBAR) OS (24) (23-1)

When (FO) operates in any of the conditions described in the preceding subsection, it operates (FO1) through front contact of (OF1). (FO1) operates (FO2) and that releases (FO3). (FO2) breaks the fundamental and also operates (AV2) and that locks up. The operation of (AV2) and the release of (FO3) remove all grounds holding (O), (BO) and (FO) and they release. The release of (FO) is followed by the release of (FO1) and (FO2).

The operation of (AV2) bridges a 500 ohm resistance across the "FT" and "FR" leads to serve as a trunk closure for the distant selector or sender and breaks off the "FT" lead from the fundamental circuit to prevent (STB) or (TG) from operating on the trunk closure.

The release of (FO2) after the operation of (AV2) breaks the operating circuit of slow relay (AV3), and that releases after a short interval allowed for the trunk closure to be effective.

RECALL OF MARKER OS (24)

For all classes except out D.P. the release of (AV3) with (AV2) operated grounds the "TRL" lead. This causes the release of (DST) and (DRL), all selection register relays locked to (DST) and all relays fed by off-normal battery, including (OF). (OF) releases (OF1), which in turn releases (IA) and (AV2), and the release of (AV2) removes ground from the "TRL" lead. A marker is called for a second or third trial as previously described.

For the out D.P. class (SOF) operated grounds the "TRL" lead causing the release of (DST) and (DRL) with the effect as described in the preceding paragraph. (OF) released, releases (OF1), followed by the release of (SOF) which removes ground from the "TRL" lead. When (OF) released upon the termination of reverse battery. The release of (DRL) releases (OF1) followed by the release of (SOF). A marker is called for a second or third trial as previously described.

TELLTALE IN OFFICE BRUSH AND GROUP SELECTION OS (25-2)

If a telltale condition is indicated in office brush selection the operation of (TT) may have been the result of a previous PCI call which was not completed due to slow dialing; or it may have been the result of trouble on an initial P.C.I. or full mechanical call. In order to determine which of the two conditions exists the first action of the sender is to obtain a reorder routing from the marker. This is accomplished as follows: (TT) operated in office brush or group operates (RR) which operates (DST) to call in a marker, with lead "OF" grounded, operates (SB2) and releases (RR1). When marker release has been received a ground through (S6') and back contacts of (RR1), back contacts of (TMM), (OG), (TMO) and (OB) operates (SA). (SA) operated disconnects (L) and (STA) from the

"T" and "R" leads and connects (P), in series with resistance (AJ) thereto. If telltale was the result of a prior PCI call which reselected a sender when all digits were dialed the originating sender will be in a position to send PCI pulses. (SA) relay by opening the fundamental has the effect of an artificial assignment and a heavy positive pulse will be received by the (P) relay. (SA) also operates (TMH) to recycle the timing and cause the operation of (BTT). When timing has been recycled as indicated by (TM1) operated a 4 to 5 second interval is measured to time for completion of PCI pulsing. If the (P) relay operates and releases before the end of the time interval the sender will release in the usual manner. However, if (P) does not operate it indicates that the originating sender was not in the trunk test position awaiting assignment but is probably waiting reversed battery in the office brush or group position. At the end of the 4 to 5 second period relay (TMO) operates to operate (RB) and release (SA). (RB) operated operates (RV1) to send a pulse of reversed battery to the originating sender. This is done in the usual manner and if the originating sender is awaiting reversed battery it will advance at the end of the reversed battery pulse. The tandem sender will cut the trunk through accept, trunk closure and release. If telltale was a result of a momentary short on "T" and "R" which has disappeared before reversed battery is applied then the trunk closure will not be received and the sender will time 3 to 6 seconds before releasing.

If the sender runs to telltale during office group selection it is probably the result of trouble in the originating sender's failure to count down. The tandem sender will set the trunk to reorder as for telltale in office brush but in this case will not test for PCI pulses. (RR) operated will operate (SB2) followed by (SB1) as described in paragraph 18.2. When marker release takes place (SB) operates and operates (RB). In this case it is possible that the originating sender may have advanced to the trunk test position when (SB2) operated to ground the tip of the line causing an additional pulse to the originating sender. The "T" lead is grounded by (SB2) in order to discharge the incoming cable prior to the disconnection of the (L) relay which follows when (SB1) operates. If the (L) relay were removed from the line without discharging the cable the cable capacity might discharge through the originating sender's (OF) relay thereby causing its false operation. (RB) operated operates (RV1) and the reversed battery cycle takes place as described in paragraph 18.2 as well as sender release.

ABANDONED CALLS OS (25-2)

An abandoned call is indicated when the originating sender drives the tandem sender to telltale after office group selection for a full selector call. For a PCI call the sender functions the same as for a completed call since the abandonment takes place after trunk test and the sender releases in the usual manner after accepting the heavy positive pulse.

If the sender is driven to telltale in any of the selections following office group and including units selection, the first effect of the eleventh pulse is to operate relay (TT). (TT) locks, short circuits (STA) and operates (LR).

ALL CLASSES EXCEPT OUT D.P. OS (24)

(LR) operated forces an incoming or final selector or terminating sender to telltale and that is done by preventing the complete satisfaction of the counting relays in the sender. A back contact of (LR) breaks the circuit from contacts of (STB) so that an incoming or final selector or sender can not operate the zero counting relays and therefore the attempt to make such a selection drives the selector or sender to telltale. (LR) also opens the ground which locks (RV3) through (SB1). This is necessary to allow (RV3) to terminate reversed battery in all final selections including IB as it can not be certain, in this selection that the originating sender has not advanced to the IG selection position where it is impossible for the originating sender to terminate reversed battery.

The distant selector or sender sends a pulse of reversed battery over the fundamental, the sender recognizes it as described for overflow and telltale and then the sender makes a trunk closure.

On a telltale caused in any way except by an abandoned call, the trunk closure is followed by the recall of a marker to make another trial. In the condition now being considered the marker is also recalled but only for the purpose of obtaining a rerouting to a reorder trunk. The necessity for a reorder trunk in this connection is to present battery and ground to the originating sender so that the trunk closure which the originating sender will provide after having recognized reversed battery will be effective in the tandem trunk.

When (AV3) releases at the termination of trunk closure toward the terminating equipment a circuit is closed thru front contact of (LR), to operate relay (RR). Relay (RR) grounds lead "OF" to the marker, and closes a ground at back contact of (TR3) front contact (RR), front contact (RR1), front contact of (OG) to cause the operation of relay (TR) or (TR2). (TR) or (TR2) operated releases (DST) and in turn all other relays locked thru (DST) and (DRL). (RR) operated also releases slow to release relay (RR1) which is slow enough to allow all operated relays controlled by (DST) to release. When (RR1) releases it removes the shunt from either (TR1) or (TR3). This allows relay (TR1) to operate in series with (TR) or (TR3) to operate in series with (TR2) and recloses the (DST) relay circuit.

OUT D.P. CLASS OS (24) (23-1)

(LR) operated opens the fundamental and releases (SSP) thereby stopping out pulsing. (LR) also operates (RR) with the effect described in the previous paragraph. In this case any terminating apparatus which is off normal will restore when the fundamental is opened.

A marker is seized with lead "OF" grounded indicating that a reorder trunk is desired. The marker after having set the reorder trunk returns a release signal to the sender in the usual manner as indicated by the operation of (DRL) and (S6) and (S6'). (S6') closes a circuit from ground thru back contact of (TMN), front of (OG), to the winding of (SB). (SB) operates and operates (RB) which operates (RV1) followed by (RV2). In this case (RV3) is locked under control of (L) so that if the reversed battery pulse is applied while the originating sender is advancing the reversed battery pulse will not be terminated until the (L) operates long enough to release (RV3). Reversed battery is applied in this manner for all incoming selections except incoming brush. For this case the operation of (RR) operates (SB2) and (SB1) and reversed battery is applied in a manner as described in paragraph 18.2. The reason for treating this condition differently is that the originating sender terminates reversed battery independently of this sender for office brush, office group and incoming brush selections. If the originating sender is in the incoming brush position the termination of the reversed battery pulse, either by the originating sender or by the tandem sender, whichever occurs first, will cause the sender to restore. However, if the originating sender terminates the reversed battery quickly or has advanced to the incoming group position the release of the sender is dependent upon the release of (RV3).

TIMING CIRCUIT AND TROUBLE CONDITIONS OS (25-2)

This section describes the timing circuit and the procedure for the handling of irregular call conditions. Briefly, the various trouble conditions are disposed of by causing the originating sender to give the subscriber or operator an overflow or reorder signal, respectively; or by setting up the connection to a reorder trunk in the tandem office.

MEASUREMENT OF TIME INTERVALS OS (25-2)

There are four interrupters used designated TM1, TM2, TM3 and TM4.

TM1 when used with relays (TMA), (TMB), (TMC), (TMD) and (TME) provides a 4 to 5 second time interval.

TM2 when used with relays (TMA), (TMB), (TMC), (TMD) and (TME) provide a 20 to 40 second time interval; a 40 to 60 second time interval or a 60 to 80 second time interval.

(TM3) when used with relay (TM3) provides an interval of approximately 1 to 2 seconds.

(TM4) when used with relays (TM5) and (RV6) provides a time interval of approximately 3 to 6 seconds.

Whenever ground is connected to either interrupters TM1 or TM2 relay (TMA) operates at once or as soon as the interrupter closes, (TMB) operates on the first break following, (TMA) releases on the second closure, and (TMB) releases on the second break. This cycle repeats as long as either interrupter is grounded.

(TMC) and (TMD) are actuated by a front contact of (TMB), (TMD) operates (TME) and the latter locks. (TMC) operates in from 0 to 1 seconds for interrupter TM1 or from 0 to 20 seconds for interrupter TM2 after either is grounded; (TMD) and (TME) operates 1 and 20 seconds later and (TMC) releases after 1 and 20 seconds more respectively. When (TMC) operates a second time with interrupter TM1 grounded a total time interval of from 4 to 5 seconds has been measured. When (TMD) and (TME) operate during the first cycle with interrupter TM2 grounded an interval of 20 to 40 seconds is measured. When (TMC) releases during the second cycle with interrupter TM2 grounded an interval of from 40 to 60 seconds is measured and when (TMD) releases during the second cycle a total interval of from 60 to 80 seconds is measured.

Recycling of Timing Relays as controlled by interrupters TM1 and TM2 is accomplished by means of relays (TMF), (PA) and (TML) which are used to terminate, and by means of relays (TMG), (TML), (TMK) and (TMM) to restart the various time intervals. By this means the timing relays, as controlled by interrupters TM1 and TM2, are constantly measuring predetermined intervals from sender seizure until (RL) operates to release the sender.

The timing circuit is so arranged that at the termination of the 40-60 second interval being measured with (RV) and (RR) operated or with (RO) operated, a circuit is closed to operate (TMR) followed by (RB) and (RV1) to release the sender.

Timing for reception of Office Brush and Office Group Selections.

When the sender is seized the TM1 interrupter is grounded from (ON2) thru a back contact of (TMF) and measures a period of from 4 to 5 seconds. If office brush and group selections are registered within this period (TMF) operates to recycle the timing circuit and when the timing relays have released (TMG) operates to restart timing on a 40-60 seconds cycle with interrupter TM1 disconnected, and TM2 connected into the circuit.

If office brush and group selections are not registered within the allotted time (4 to 5 seconds) relay (TMO) will be operated from ground on (ON2), back contact of (TMF) front of (TME), front of (TMC), back of (TMD) to winding of (TMO). (TMO) operated locks and operates relay (TH) which operates (RB). (RB) locks, short-circuits (STA) to prevent pulsing from starting and operates (RV1) to transmit reversed battery to the originating sender as described for incoming advance. With (TH) operated a ground is connected to the "DC" lead when (CK3) operates during the check, made between sender and trunk prior to disconnection. A relay in the through supervision trunk will be operated to provide battery and ground for the reception of trunk closure by the trunk line relay if the sender accepted reversed battery. The sender releases immediately if trunk closure is received or within 3 to 6 seconds.

When office group selections are registered a ground through a front contact of (OG) operates relay (TMF) which disconnects ground from interrupter TM1 and all operated timing relays release. When all operated timing relays are normal relay (TMG) operates, locks and connects ground to interrupter TM2 and to the locking contacts of the timing relays and this starts a 40 to 60 second cycle.

TIMING AFTER OFFICE BRUSH AND GROUP REGISTRATION FOR A FULL MECHANICAL CALL OS (25-2)

A 40 to 60 second cycle is allowed from the registration of office group selections till sender release for a full selector call. If the sender is released within this period all timing relays will release when the sender releases. If, however, the sender has not released within this period the timing relays will close a circuit to operate (TMJ) followed by (TMP) when (TMC) is released and with (TMD) and (TME) operated. Relay (TMP) operates locks and operates (LR) and the call is disposed of as described for an abandoned call. (TMP) also operates (TMH) to recycle the timing circuit and when all operated timing relays have released (TM1) operates to measure a second 40-60 second interval. If the sender fails to release at the end of this period (TH) is operated through front contacts of (TMQ) followed by (RB) and sender release.

If after office brush and group selections have been registered and the sender fails to obtain the services of a marker due to a trouble condition within 40 to 60 seconds relay (TH) will operate and set the trunk hold relay as described in Paragraph 21.32.

TIMING AFTER OFFICE BRUSH AND GROUP REGISTRATION FOR A PCI CALL OS (25-2)

TIMING FOR PCI CALL

An interval of 40-60 seconds is allowed for the originating sender to complete dialing. This time is measured from the registration of office brush and group selections. If the sender (S) relay fails to operate for trunk test within the allotted time a circuit is closed through contacts of (TMC) released and with (TMD), (TME) and (CI) operated to operate (TMJ) to operate (TH) which will operate (RB) followed by (RV1). (RV1) will send reversed battery to the originating sender; the trunk hold relay will be operated and the tandem sender will release as previously described.

If trunk test is made within the allowable time (S) and (SA1) will operate. (SA1) operates (TMH) which disconnects ground from interrupter TM2 and associated relays causing their release. When the timing relays have restored relay (TMI) operates, locks and reconnects ground to interrupter TM2 and associated relays for measuring a 60 to 80 interval for assignment.

If assignment is made within the allowable time and sender will restore in the usual manner.

If assignment is not made within the allotted time of 60-80 seconds relay (TMN) will operate through back contacts of (TMC) and (TMD) and front contacts of (TME) and (SAI) and cause the operation of (PA). (PA) operated connects resistance battery and ground to the "T" and "R" leads for the purpose of preventing an assignment at this time and recycles the timing relays for a 40-60 second cycle by the operation of (TMK). (PA) also operates relay (RR) for the purpose of calling in a marker to obtain a reorder routing. The marker after having set the call to reorder transmits a marker release to the sender in the usual manner. When (S6') operates following marker release relay (SA) operates and locks to (PA). (SA) disconnects battery and ground from the "T" and "R" leads and connects relay (P) across the "T" and "R" leads in series with resistance (AJ). This has the effect of an artificial assignment; PCI pulses will be transmitted and the (P) relay will operate on the heavy positive pulse and the sender will be restored in the usual manner. When assignment was simulated relay (TML) operated to stop the 40-60 second cycle and when the timing relays have restored (TMM) operates to start a 4-5 second interval for the reception of a heavy positive pulse. If (P) fails to operate after the 4-5 second period for either a regular or the artificial assignment being described (TMO) operates to restore the sender by operating (RB) and (RV1). At the end of the 40-60 timing period, started by the operation of (TMK), when a reorder routing is requested, if a trouble occurs so that a marker release can not be obtained a circuit will be closed to operate relays (TMJ) and (TH). The sender will release with the hold relay operated in the trunk.

TIMING FOR STRAIGHTFORWARD CLASS CALL OS (25-2)

Following marker release for a straightforward class call a circuit is closed through a front contact of (OD) to operator (TMH) to recycle the timing. (TMH) operates (BTT) through a front contact of (OD1) and this connects the (TM1) interrupter into the timing circuit to measure a 4 to 5 second time interval. If trunk test is not completed at the end of this 4 to 5 second interval (TMO) operates followed by (TH) and (TMR) to operate (RB) and the sender releases as already described with the incoming trunk set in the no-connection position.

TIMING FOR TRUNK TEST FOR FULL SELECTOR CALLS OS (25-2)

When a full selector call is indicated by the operation of (RV) and with (FO3) operated ground is connected to interrupter (TM4) and starts a 3-6 second interval. The "B" contact of interrupter operates (TMS) which locks; approximately 3-6 seconds later if trunk test has not been completed "F" of (TM4) will operate (TG2). (TG2) locks and releases (TST); (TG2) also releases slow to release relay (TG3) which when released reoperates the (DST) relay with the effect of calling in a marker for the purpose of getting a trouble indicator record. (TG2) when operated grounds lead "TGF" to the marker. The marker after calling in a trouble indicator grounds the (TRL) lead and that allows the sender to make a second trial in the usual manner. Failure to complete trunk test on the second trial trunk sticks the sender until the 40-60 second time-out period has elapsed and then (TMP) operates followed by (LR) and (TMQ); the 40-60 time interval is recycled and the sender calls in a marker and routes the call to overflow. If the sender fails to release at the end of the second 40-60 second interval (TH) will operate and a second try will be made to release the sender.

TIMING FOR SENDER RELEASE FOR FAILURE OF TRUNK TO CHECK FOR TRUNK CLOSURE OS (25-2)

If for any reason the trunk fails to return a ground on the "D" lead during sender release the sender is automatically primed after a 3 to 6 second time-out. When (PA3) releases prior to sender disconnect a circuit is closed to operate (RV6). (RV6) grounds interrupter (TM4) whose back contact "B" operates (TMS) and whose front contact "F" 3 to 6 seconds later operates (CP) followed by (RL). This causes sender release.

If for any reason it is desired to hold a sender for trouble tracing the (CP) key at the sender make busy frame is operated. When (CP) operates at the end of the 3 to 6 second time out period a circuit is closed to hold the (ON1) relay through contacts of the units hold magnet and the (CP) key. The link is released but the sender holds. This key however, is effective only on full selector calls when all digits have been registered.

TIMING FOR (L1) TO OPERATE WHEN CALL IS ABANDONED BY ORIGINATING SUBSCRIBER OS (25-1)

If a call has been abandoned, during the registration of incoming and final selections, after the fundamental circuit has been closed long enough to operate (L) (L1) and (L2) relays and release (SM) but before one or more pulses have been sent, the opening of the fundamental at the originating end will release (L), (L1) and (L2) and since no pulse has been sent the reclosure of the fundamental, for registering a telltale condition, will reoperate (L) but (L1) can not operate since (SM) is released. In order to prevent stuck senders when this condition occurs a circuit is closed from front of (L), back of (SB1) and (L2), back of (SM), front of (OG) to interrupter (TM3). Contact "B" of this interrupter operates (TM3) and if (SM) has not operated by the time "F" of interrupter closes its contact it operates (TT). (TT) operates (LR) and the terminating apparatus is restored in the usual manner. A marker is called in and the call routed to a reorder trunk.

STUCK SENDER AND SLOW COMPLETION LAMPS OS (25-2)

A stuck sender lamp is lighted if the sender fails to release, after the 3 to 6 second interval allowed for it to do so. (CP) operates after the 3 to 6 second interval and causes the operation of (RL), if this relay has not already operated. (RL) operated released (STS) and that in turn grounds lead "L" to light a lamp at the make busy frame indicating a stuck sender. (STS) released also grounds a common alarm lead.

The sender normally times out in 60 to 80 seconds awaiting assignment for PCI class calls. If a number of senders are held busy by slow assignment so that the sender load alarm is brought in, the lighting of a slow completion lamp will indicate a sender which has timed 40 to 60 seconds. In this case when the 40 to 60 interval has elapsed a circuit is closed through front of (TMJ), which operates at the end of the interval, front of (SA1) and back of (SA2) to the "L1" lead. The lamp is extinguished by the operation of (SA2) when assignment takes place. To relieve the condition of slow assignment tying up senders a jack is provided on the sender make busy frame per group of senders which when plugged up causes leads, designated "ST" and "ST1" to be connected. This in effect reduces the awaiting assignment period from 60 to 80 seconds to 20 to 40 seconds.

OPERATION OF REGISTERS OS (25-2)

Three trouble registers common to a sender group are provided to indicate sender time-out as follows:

Awaiting dialing register (AD). This register will operate on a full selector call if incoming and final selections have not been registered in 40 to 60 seconds; or on a PCI call if the (S) relay does not operate in 40 to 60 seconds. In the case of a full selector call, the register is operated when the 40-60 time interval has elapsed. This operates (TMJ) followed by the release of slow release relay (RCO). A pulse of current is transmitted to the register from ground front of (ON1), (TMJ) and (RCO), front of (RV) back of units hold magnet to lead "AD". When (RCO) releases the circuit is opened so that only one pulse is transmitted to the register (AD). In the case of a PCI call this circuit is carried through a back contact of (RV) and a front contact of (CI) and back contact of (SA1) to operate the register.

AWAITING OB AND OG REGISTRATION REGISTER (AR) OS (25-2)

This register will operate if (OB) and (OG) selectors are not registered within the prescribed time. The sender will send reversed battery at the end of

4 to 5 seconds and then await trunk closure for 3 to 6 seconds. If a trunk closure is not received at the end of the 3 to 6 second period the awaiting register will operate. When (CP) operates at the end of the 3 to 6 second period a circuit is closed from ground through front contact of (STS) front contacts of (CP) and (RCO) to the "AR" lead thereby operating the (AR) register. Subsequent release of the sender and (STS) relay opens the circuit to the "AR" lead.

STUCK SENDER REGISTER (SS) OS (25-2)

This register will operate for a full selector call after the initial 40 to 60 second interval if incoming selections have been completed; for any class of call if sender fails to release after the automatic priming feature has failed to release the sender; for any class call if sender times 40 to 60 seconds and can not get a marker; any one of these conditions will momentarily ground the "SS" lead through a contact of (RCO) which releases due to the operation of (TMJ) or the release of (SS).

OVERSTEP OF SELECTION SWITCH OS (25-2)

If during the reception of office brush selection, when "L" and "Z" wiring is employed, a registration appears on the unused switch levels 5, 6, 7, 8 and 9 an overstep is indicated. In this case when OG selections have been made a circuit is closed from OG through one of the 5, 6, 7, 8 or 9 crosspoints of the OB vertical to operate (RR). This will cause the marker to be called in with lead "OF" grounded to indicate a reorder routing. When a marker release is received the (SB) and (SB1) relays will operate followed by the (RB), (RV1), (RV2), (RV4) and (RV5). Reversed battery will be connected to leads "T" and "R" until a closure is received from the originating sender. The sender will release as described for an "all trunks busy" condition.

An overstep is also indicated for incoming brush, incoming group, and final brush selections if an unused switch level crosspoint is closed. If such a closure appears on the incoming brush vertical both the (TT) and (SB2) relays are operated; if a closure appears on the incoming group or final brush vertical the (TT) only is operated. The reason for this discrimination is that for telltale (no crosspoint closed) in incoming brush this sender transmits reversed battery to the originating sender when the fundamental is closed and awaits a termination by the originating sender whereas for overstep (crosspoints closed) reversed battery is applied when the originating sender closes the fundamental and the originating sender awaits its termination. (TT) operated in any one of these selections causes the sender to function as for an abandoned call. (SB2) being operated for the incoming brush condition prevents (RV3) from terminating reversed battery.

CABLE FAILURE

Short-circuited trunks will send the sender to telltale in office brush registration and will be set up to reorder trunks as long as reorder trunks are available. When all reorder trunks are busy the hold relay in the trunk will be operated from the sender. The detailed operation is the same as described for telltale in office brush selection.

Trunk with grounded tip. This will cause sender seizure but there will be no selections. The sender will therefore time-out in 4 to 6 seconds and operate the trunk hold relay as described in Paragraph 21.32.

Trunk with grounded ring. This will not produce a sender seizure until the trunk is seized by an originating sender. With the ring grounded there can be no selections. The sender will time out in 4 to 5 seconds and operate the trunk hold relay as described in Paragraph 21.32.

RELAY FAILURES

Failure of (OF) relay to release. If the (OF) relay fails to release, due to a faulty adjustment (ON1) will hold from the (OF) relay. The sender will stick and bring in the stuck sender lamp and alarm.

Failure of (TC) relay to release. If for any reason relay (TC) fails to release, relays (RL) and (RV6) will hold from (TC). Relay (CP) will operate in 3 to 6 seconds and close ground from the back contacts of (STS) to leads "L" and "A" to bring in the stuck sender lamp and alarm.

Short-circuited contacts on (STA) relay. If for any reason the contacts on relay (STA) becomes short-circuited, relay (GR) will hold operated and will hold (ON1) operated after the operation of (RV1). The sender will stick and bring in the stuck sender lamp and alarm.

PANEL CALL INDICATOR CALL

OS- (24) (23-1)

CI

If the office brush group selection code information sent to the tandem marker represents a P.C.I. class of call, the marker grounds the CI lead operating the CI relay during the decoding of the code. The CI relay in operating, indicates to the sender that no more revertive pulses will be received from the originating panel sender. It then awaits the release of the marker connector, which indicates that a trunk to the distant office has been selected and the marker is proceeding to select a channel between the selected outgoing trunk and the tandem trunk originating the call. When the channel is selected and closed through satisfactorily the sender DC relay releases, operating the S6' relay causing the P.C.I. call to proceed for trunk test.

P.C.I. TRUNK TEST OS (22)

CI1

The CI1 relay in operating removes the short-circuits from both windings of the P relay and connects it into the fundamental circuit.

CI2

The CI2 relay in operating removes the short-circuits from both windings of the S relay and connects it into the fundamental circuit, in series with the P relay. The polarity of the S relay windings are opposite to that of the P relay windings, since each one will check for one of two directions of current in the fundamental circuit. The CI2 relay is slow operate to keep the S relay windings short-circuited momentarily to prevent the false operation of the S relay due to cable charge when the CI1 relay operates prior to a trunk test closure by the originating sender.

S

The S relay in operating indicates that P.C.I. trunk test has taken place. The S relay receives battery on the FT lead and ground on the FR lead from the terminating office. The operating path is traced as follows: battery on the FT lead, back contact CK3 relay, front contact of CI1 relay, back contact of PA and SA relays, secondary winding of P relay, P2 winding of S relay, back contact of RV7 relay, front contact of ON1 relay to T lead back on R lead, front contact of ON1 relay, back contact of RV7 relay, P1 winding of S relay, primary winding of P relay, back contact of SA and PA relays, front contact of CI1 relay, back contact of CK3 relay to ground on FR lead.

SA1

The operation of the SA1 relay, operates the TMH relay causing the TM2 interrupter to start a cycle of timing for awaiting assignment, as explained later.

ASSIGNMENT OS (22)

S

When assignment takes place at the terminating office, battery and ground are removed from the fundamental leads, releasing the S relay.

SA2

The operation of the SA2 relay operates the TML relay causing the TM1 interrupter to start a timing cycle for awaiting the completion of the transmission of P.C.I. pulses. The TM2 interrupter is opened by the operation of the TML relay ending the timing for assignment.

The operation of the SA2 relay reapplies a short-circuit or both windings of the S relay, preventing any reoperation of this relay.

HEAVY POSITIVE PULSE OS (22)

P

The P relay in operating indicates that the heavy positive pulse has been applied as a signal that P.C.I. pulses are completed. The P relay operates from battery on the T lead and ground on the R lead from the originating office. The P relay is operated only for the duration of the heavy positive pulse at which time it releases.

PA1

When the locking contact closes on the PA1 relay, a short-circuit is applied to the winding of the PA2 relay until the P relay releases at the completion of the heavy positive pulse.

PA2

When the PA2 relay operates, it applies an additional ground to the SB lead for holding the sender busy.

FIRST TRIAL - TROUBLE RELEASE DURING MARKER CONNECTOR STAGE

OS (24)

TR

If the first marker encounters trouble in receiving information from the sender in decoding or in transmitting information to the sender, it sends a trouble release signal by grounding the "TRL" lead, causing the sender to release the connector, which in turn releases the marker, breaking all direct connections with the sender. The sender then sets for a second trial, connecting to a second marker. This may be the same marker as before but usually will be a different one, since the first marker holds itself busy momentarily after sending a trouble release.

ST & CBS LEADS

Upon release of the DST relay, battery is removed from the ST and CBS leads to allow the marker connector to release, in turn releasing the marker.

TR1

After the TR relay operates, the TR1 relay is short-circuited until ground is removed from the TRL lead, at which time the TR1 relay operates in series with the TR relay. The TR relay is locked through the series circuit. The operation of the TR1 relay removes ground from the TR1 lead and connects it to the TR2 lead toward the marker connector in preparation for registering a second trial in the second marker when selected.

FIRST TRIAL - TROUBLE RELEASE AFTER CONNECTOR STAGE

OS- (24)

TR

After the marker has selected a trunk to the terminating office, it causes the connection via the connector to be released, while maintaining communication with the sender through the trunk link and sender link frames. The marker then proceeds to select a channel, between the trunk link and office link frames. If during this period the marker encounters either trouble or an all channels busy condition, it sends a trouble release signal by grounding the "D" lead through the trunk link and sender link for a moment only.

The sender DC relay being operated connects the "D" lead to the TR relay, which operates from this momentary ground.

DST

Since under this situation, a release signal has been received from the marker, releasing the connector, the CRl, 2 or 5 register relays are locked in under control of the DST relay and therefore release upon the release of this relay the DST relay, also releases the DRL relay in preparation for another release should trouble be encountered in the second marker.

SECOND TRIAL - TROUBLE RELEASE

OS- (24)

TR2

If during a second trial, a trouble is encountered, the TRL lead or D lead will be momentarily grounded a second time, causing the TR2 relay to operate, due to the TR and TRl relays being operated and locked from the first trial. The operation of the TR2 relay, releases the DST relay, causing the release of the marker, as explained for a first trial trouble release.

TR3

During the time that ground is connected to the TRL of D lead, the TR3 relay is short-circuited; when ground is removed from these leads the TR3 relay operates in series with the TR2 and the TR2 locks. The TR3 relay removes the ground from the TR2 lead from the connector.

RR

The operation of the RR relay connects ground to the OF lead toward the marker connector in preparation to notify the third marker of a third trial and that it should establish connection to an overflow trunk.

The RR relay removes ground from the office group leads G-0 to G-4 and GA5 or GB5, preventing the office code from being registered complete on a third trial.

The RR relay operates the DST relay causing the selection of a third marker. The third marker connects the tandem trunk to an overflow trunk and releases the sender DC relay as in a first trial call.

THIRD TRIAL - TROUBLE RELEASE OS (24)

TR2

If during a third trial, a trouble is encountered the TR, TRl, TR2 and TR3 relays being operated and locked

RO OS (24)

The RO relay in operating operates the DRL relay to release the connector if still engaged. It also operates the SB relay, which in turn operates the RB relay. The RB relay causes the tandem sender to function and send reverse battery to the originating sender as in a regular call.

If the originating sender is set for incoming trunk test the reverse battery completes the test causing the OF relay to operate in incoming brush selection; the panel district being advanced to overflow position. The tandem sender applies the reverse battery, as explained later, for "all trunks busy."

If the originating sender is set for a selection after incoming brush but before incoming advance, the reversed battery is applied as for a regular call.

If the originating sender is set for incoming advance, the reverse battery causes the OF relay to operate and the panel district is advanced to talking position. The reversed battery is applied in this case as for a regular call.

If the originating sender is set for P.C.I. trunk test, the OF relay operates and the panel district is advanced to overflow position.

The tandem trunk is signalled for trunk closure in any of the above cases and the tandem sender releases.

The fact that this is a trouble release on a third trial call and that the marker has failed to close any channel crosspoints from the tandem trunk to an outgoing trunk, the calling subscriber is left connected to the tandem trunk with no possible signal for release, if the originating sender was set for incoming advance. This condition is unavoidable since all trials have been exhausted and it is not possible to make any discrimination on reverse battery when the originating sender is set for incoming advance. If the originating is set for incoming or P.C.I. trunk test, the tandem trunk is released when the panel district advances to the overflow position.

M. F. SENDER
SD-25769

M. F. SENDER
SD-25769

MULTI-FREQUENCY SENDER CIRCUIT (SD-25769)
WITH
RECEIVING CIRCUIT (SD-95087)

Multi-Frequency Pulsing

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MULTI-FREQUENCY SENDER CIRCUIT (SD-25769)

WITH

RECEIVING CIRCUIT (SD-95087)

MULTI-FREQUENCY PULSING

PURPOSE

MULTI-FREQUENCY SENDER CIRCUIT

This circuit is used in a tandem crossbar office to complete calls from manual, D.S.A., and toll switchboard positions, equipped for M.F. key pulsing or senders arranged to transmit multi-frequency pulses. It is used to complete calls to panel, crossbar terminating, crossbar R.P. tandem, manual step-by-step and panel sender tandem offices; and to operator and desk positions.

RECEIVING CIRCUIT

This circuit is used in multi-frequency pulsing systems to receive signals in the form of pulses of voice-frequency current from a trunk, key set, or sender and to convert the signals to direct current pulses to operate various code combinations of relays in an associated sender, key monitoring circuit, automatic monitor, register circuit, sender, or position test circuit.

GENERAL DESCRIPTION

MULTI-FREQUENCY SENDER FRAME

The multi-frequency sender frame is a single bay structure mounting three sender units. The three senders mounted on one frame are numbered 0 to 2. The sender frames are numbered from 0 up in the office and may start as 00 or 100 depending upon whether it is the first or second unit in the building.

The M.F. senders are arranged for five senders to a subgroup. The grouping starts from the first sender frame and runs consecutively throughout all sender frames. With this arrangement, a subgroup may have included the senders from either two or three sender frames.

Each subgroup of five M.F. senders are connected to each of the tandem sender link and controller frames which it serves by several leads which are connected into any one individual sender for a short time when it is first seized for service.

These are the GS, SL and RL leads which assist the link controller circuit in its functions; 12 numbered F leads for registering in the sender the number of the tandem trunk link frame; the class of trunks by leads CS-0 to CS-6 and the HM lead which supplies the initial operating ground for the sender link hold magnets.

Each sender is connected individually to the sender link and controller circuit by 11 leads, T, R, FT, FR, CO, D, DC, S, SC, SB and BS.

The sender is connected through the tandem marker connector to a tandem marker for a fraction of a second on each call. A plurality of wires are involved in this connection for mutual control and transmission of information in both directions.

MULTI-FREQUENCY RECEIVER FRAME

The multi-frequency receiver frame is a single bay structure mounting six receiving units, numbering from 0 to 5. These frames are numbered from 0 up in the office and may start as 00 or 100 depending upon whether it is the first or second unit in the building.

Each receiving unit is permanently connected to one multi-frequency sender. It functions with the sender over a group of 20 leads.

CENTRAL OFFICE BATTERY AND GROUND

At this point, it should serve well to remind those who are starting contact with the receiving circuit that the central office battery is grounded on the positive side. This is pointed out for the purpose of appreciating the terminology of positive bias and negative bias, which shall be used in describing the receiving circuit, that it means central office ground and central office battery, respectively. That the positive bias requires the use of the ground convention and that negative bias requires the use of the battery convention. It may also be expressed as positive potential or negative potential.

M.F. RECEIVING CIRCUIT

There are nine pentode beam-power type vacuum tubes in a receiving unit. The pentode vacuum tube is a five element tube, not counting the heater. There are six connections to a tube, numbered 2 to 8. The following is the association of the elements in this tube with the connection numbering.

Heater	No. 2 & No. 7
Cathode	No. 8
Control Grid	No. 5
Screen Grid	No. 4
Beam Forming Plate	(Connected to cathode)
Plate	No. 3

The vacuum tubes must be energized for the receiving circuit to be operative. They will normally be left on continuously except when the circuit is taken out of service.

The heater of the L1 and L2 tubes are wired in series and in parallel with the heaters of the 0 and 1 tube which are in series. These tubes us A negative battery at the BCO jack to A positive ground through the H1, H2 and H3 resistances in series.

The heater of the 7 and 10 tubes are wired in series and in parallel with the heaters of the 2 and 4 tubes which are in series. These tubes use B negative battery at the BCO jack to A positive ground through the H4, H5 and H6 resistances in series.

The heater of the SP tube uses the C negative bettery at the BCO jack to positive ground through H7, H8 and H9 resistances in series.

The L1 and L2 tubes are wired for push-pull amplification and are known as the limiter tubes. The plates of these tubes are receiving their positive potential from the L 54W coil, this coil functioning as an auto-transformer. Their screen grids have a positive potential, fed in a potentiometer arrangement from battery on the FLT repeat coil and ground on the P1 and P5 resistances.

The SP tube is known as the signal present tube, its screen grid having a fixed positive potential. The plate of this tube receives its positive potential from the T1 jack through the secondary winding of the SP relay causing this winding to be energized in the released direction during its statical period.

The 0, 1, 2, 4, 7 and 10 tubes are known as the channel tubes; the screen grids receiving their positive potential from the KP-2 and KP-3 relays while the receiver is locked or from the back contacts of their associated channel relay during the statical period after the receiver is unlocked. During the operation of the receiver these screen grids receive a lower positive potential through the primary windings of the CK-1, CK-2 and CK-3 relays. The plates of these tubes receive their positive potential through the secondary winding of their associated channel relay, thus energizing these windings in the release direction during their statical period.

The SP and channel tubes are operated as detectors.

The cathodes of all vacuum tubes in the receiver, receive their negative bias from the FLT repeat coil, this bias being shunted by a positive potential on the back contacts of the SP relay during the statical period.

The control grids of the L1 and L2 tubes are biased negative with respect to the cathode during their statical period and the control grids of the SP and channel tubes, for all practical purposes, are at 0 potential with respect to the cathodes in their statical period.

The filters 0, 1, 2, 4, 7 and 10 are band-pass filters, rated to pass their associated frequency, + or - 45 cycles.

SEIZURE

SC LEAD

When a multi-frequency tandem trunk calls for a multi-frequency sender, the tandem sender link and controller circuit in its functions selects a sender subgroup and removes it from service on other tandem sender link frames. The controller then selects an idle sender in the group by operating an S- relay. Upon the operation of the S-relay, ground is connected to the SC lead to the M.F. sender.

HM LEAD

The SC-1 relay connects ground to the HM lead to operate the sender link primary and secondary hold magnets thereby connecting the incoming trunk to the selected sender.

When the crosspoints are closed, 8 individual leads are closed to the sender, 7 of these leads T, R, FT, FR, DC, CO and D are connected straight through from the sender to the trunk. The 8th lead S is connected to the hold magnets of the sender link switches.

S & S1 LEADS

These 2 leads are connected together by the operation of the SC-1 relay for the purpose of sleeve continuity check between the link secondary crosspoints and the sender. Operation of the link controller SL relay is an indication of sleeve continuity. The SL relay, together with the ST relay connects ground to the GS lead to the sender.

CLASS OF CALL INDICATION AND TRUNK LINK FRAME REGISTRATION

CS-0 TO CS-6

The operation of the SC-1 relay connects leads CS-0 to CS-6 for the operation of the proper class-of-service relay from ground in the sender link controller circuit. The ground is supplied on the basis of trunk grouping and the type of tandem sender being used.

No class-of-service relays are required if all trunks served by the sender group are of the same class with respect to the sender, and to the handling of terminating codes by the marker, as to routing, denial of service or otherwise.

There may be ten classes-of-service provided by the combination of the CS-0 to CS-6 relays, as follows:

Class Indication	CS- Relays	Class Indication	CS- Relays
0	0 & 5	5	0 & 6
1	1 & 5	6	1 & 6
2	2 & 5	7	2 & 6
3	3 & 5	8	3 & 6
4	4 & 5	9	4 & 6

While the combination of CS- relays operated from the sender link has a definite pattern, the indication for the class-of-service to the tandem marker is flexible. Therefore, it requires cross-connections between the CL punchings on the CS- relays to the CS-0 to 4 punchings to the marker connector. Only CS-0 to CS-4 punchings to the marker connector will be used for the present as follows:

Class Ind. In Sender	Terminals Cross-Connected CL to CS
0	0 - 0
1	1 - 1
2	2 - 2
3	3 - 3
4	4 - 4

If more than one of the CS-0 to CS-4 relays are operated because of trouble, a path is closed to operate the CHK relay through either its primary or secondary winding. The ground is supplied from either the No. 2 top CS-0, No. 4 top CS-1, CS-2 or CS-3 relay.

F0 TO F9 LEADS
F00 OR F10 LEAD

It is the function of the sender link frame to give to the sender in a combination of F- leads the frame number of the associated trunk link frame so that this information may be passed on to the tandem marker for its use in selecting this frame for the call. The SC-2 relay, when operated, connects these leads to operate one of the frame relays F0 to F9, and either F00 or F10, corresponding to the trunk link frames 0 to 9, or 10 to 19, respectively.

The F-0 to F-9 relays and the F-00 or F-10 relay, when operated, connects ground to their respective F- lead to the marker connector circuit.

If more than one of the F-0 to F-9 relays are operated, because of trouble, or if both the F-00 and F-10 are operated, ground is connected through the contacts of these relays to operate the CHK relay on its secondary or primary windings.

OFF-NORMAL

Temporary off-normal ground is connected to certain parts of this sender as soon as the class-of-service or frame identification is registered in the sender. When the F-, F-00 or F-10, or the CS-0 to CS-6 relays operate, ground is connected to the GD1 off-normal ground lead causing the CK-4, AV-3, OF-2 and SR relays to operate.

SR

The SC-1 relay, in operating, closes the operating path for the SR relay, but this relay holds independent of the SC-1, after the L relay operates.

The SR relay is operated in this manner to prevent the sender link from timing out if the call is abandoned just after the link passes the point where it can recognize the wipeout and before the sender is in position to recognize it.

ON-1

The HM lead ground, which was used to operate the sender link switch hold magnets, is extended by the crosspoints closure to the S lead to the sender and back to the sender link over the SL lead for sleeve continuity test. Satisfied by this that the sender is ready for the next step, and after making a test to guard against double connections, the sender link then grounds the GS lead which operates the ON-1 relay.

If the CHK relay has operated due to the operation of more than the correct number of frame relays or class relays, the operation of the ON-1 relay is prevented, causing the sender link and controller circuit to time-out.

The ON-1 relay contacts supply ground to the off-normal ground leads GD1, GD3, GD4 and GD5 until the sender disconnects. Ground being connected to the GD1 lead causes a holding circuit to be connected to the CK-4, AV-3, OF-2 and SR relays and a locking circuit to be connected to the F-, F-00 or F-10 and CS- relays operated.

L

The ON-1 relay operated closes the tip and ring from the trunk circuit, which are connected in series with the primary coils of the repeat coil in the receiving circuit to the primary and secondary windings of the sender L relay, causing its operation. The L relay battery and ground are connected to the tip and ring, respectively, in order to match the battery and ground in the trunk circuit. This is necessary so that no reversal be sent at this time to the originating office while the supervision of the call is being transferred from the trunk to the sender.

CO

The ON-1 relay operated connects ground to the CO lead to the trunk circuit, operating the trunk T relay and causing the trunk battery and ground on the A relay to be disconnected from the tip and ring, respectively. This causes the trunk A relay to release.

TM1

When the ON-1 relay operates and grounds the GD1 lead, this ground is connected through the break contacts of the STS relay, break contacts of AL-1 relay to the TM2 interrupter to start the first timing cycle as explained later. If the B contact of the TM2 interrupter is making at this time, the TM-1 relay operates and locks.

SB LEAD, ON-2 & ON-3

The ON-1 relay operated grounds the SB lead to the selector circuit (subgroup) and operates the SB relay, making the sender busy. The SB relay in operating grounds the BS lead to the sender operating the ON-2 and ON-3 relays in series. The path for operating the ON-2 and ON-3 relays is taken through the F-00 or F-10 relay operated, the F-0 to 9 relays operated, the CS-5 or CS-6 relay operated, the CS-0 to 4 relays operated and the SR1 relay operated. This operating path checks that a complete registration for the frame number and class-of-service has been made and that the L, SR and SR1 relays are operated.

The ON-1 and ON-2 relays lock each other up, the ON-2 holding the ON-3 relay.

The ON-2 relay, in operating, grounds the S and RL leads to the sender link. The S lead ground is for the purpose of holding operated the link hold magnets after the sender link has released and until the sender has finished its functions. The grounding of the RL lead is a release signal to the sender link and controller circuit.

SC-1 & SC-2 RELEASE

The release signal to the sender link and controller circuit causes ground to be removed from the SC lead, releasing the SC-1 and SC-2 relays which break the connection of the common leads into the sender; but the sender remains connected to the incoming trunk by the individual leads through the sender link switches until it has completed its work.

BAT1, BAT2 & BAT3 LEADS

When the ON-3 relay operates, it connects battery to the BAT1, BAT2 and BAT3 leads to the receiving circuit.

The battery connected to the BAT2 lead is connected to the secondary windings of the CK-1, CK-2 and CK-3 relays in a parallel series circuit to ground at the T3 jack, energizing these windings in the release direction. These relays are biased polarized relays. The primary windings of these relays are connected in series from ground at the T3 jack to the network resistances OB, 1B, 2B, 4B, 7B and 10B to battery on the BAT1 and BAT3 leads, these batteries being shunted by grounds on the back contacts of the KP-2 and KP-3 relays. Therefore, at this time there is no current flowing in the primary windings.

It should be noted that that the battery on the BAT1 and BAT3 leads and the primary windings of the CK-1, CK-2 and CK-3 relays, together with the OB and OC to 10 B and 10 C resistances form a potentiometer circuit which becomes associated with the screen grids of the vacuum tubes 0, 1, 2, 4, 7 and 10. These batteries are connected in preparation for changing the screen grid voltage when the receiving circuit is in operation.

At this stage of the call, the receiving circuit is considered locked, for as long as the KP-2 and KP-3 relays are normal ground on the break contacts of these relays are holding the screen grids of vacuum tubes 0 to 10 at normal potential.

The battery on the BAT2 lead is also connected to the primary winding of the KP-1 relay, this current being in the operate direction, although it does not operate the relay at this time. This is because the secondary winding is always energized while the receiving circuit is normal from battery on the T5 jack to ground on the break contacts of the 2 and 10 channel relays. The current in the secondary winding is in the released direction and always overpowers the primary winding while energized. It will be noted that the KP-1 and KP-2 condensers are short-circuited at this time by the same grounds that are energizing the secondary winding of the KP-1 relay. The KP-1 relay is a non-biased polarized relay.

TO

The TO relay is a non-biased polarized relay. The operation of the ON-3 relay energizes the tertiary winding to insure that the relay is on its back contact or during its release period to drive it down. A non-biased polarized relay has no coil spring to return the armature to its back contact when it is supposed to release, therefore, the tertiary winding is used for this purpose.

SENDER PREPARED FOR REGISTRATION

Eight-digit registers of five relays each, such as the A0, A1, A2, A4 and A7, are provided for the A, B, C, thousands, hundreds, tens, units and stations digits. In some cases auxiliary relays are required to provide sufficient contacts, such as the A1A to A7A, TH0A to TH7A, IGH, H7A and TA5. In addition, provisions are made for the registration of the initial "1" associated with service codes through the use of the 11A and 11A' relays.

The registration leads 0, 1, 2, 4 and 7 from the receiving circuit are transferred successively from digit to digit by means of a walking circuit consisting of a pair of relays per digit, such as AA and AB, BA and BB, etc., to SA and SK. These pairs of relays are all operated before registration starts, and are released consecutively as registration proceeds.

AA & AB

The operation of the ON-3 relay by its top No. 4 and No. 5 contacts, connects ground to the GD2 off-normal ground lead through back contacts of SA and AL-1 relays to the windings of the AB and AA relays in series, operating these relays; the AB locking and AA holding. This off-normal ground is then connected to the windings of the BA and BB relays which operate. The process continues, the BB operating CB and CA relays, the CB operating the THB and THA, etc., until finally the SA and SK relays are operated.

START PULSING SIGNAL

RV-1

From the beginning of the call, when the incoming trunk A relay was operated, until this point is reached in its operation, the originating office has been waiting for a signal to start pulsing. This signal is reversed battery, that is, battery on the ring and ground on the tip.

With the tip and ring of the incoming trunk now cut through to the tandem M.F. sender, the sender prepared for registration and the receiving circuit ready, the operation of the RV-1 relay causes the battery and ground on the windings of the L relay to be reversed and connected to the ring and tip, respectively, as the signal for start pulsing.

MULTI-FREQUENCIES

This type of call from an originating office to the tandem office is on a multi-frequency basis. This consists of transmitting two frequencies of various combinations for each digit required. Each multi-frequency call is preceded by a preliminary KP signal to unlock the receiving circuit and an ST signal to denote the end of the call. The ST signal is required because a call may consist of 3, 7 or 8 digits. Three digits of only a service code is to be received, 7 digits consisting of an office code and 4 numerical digits if the call is for panel, crossbar or manual offices having no numbers over 10,000 and 8 digits consisting of an office code and 5 numerical digits if the call is to a manual office having numbers over 10,000 or party lines.

The multi-frequency signals may be sent out by an operator using a keyset which connects the proper frequencies for each digit to the trunk or by another sender. The two frequencies for each digit are received instantaneously. The multi-frequencies are a-c voltages, superimposed onto the tip and ring d-c circuit, which is being supplied by the battery and ground on the M.F. sender L relay.

The signalling frequencies used for the multi-frequency pulsing are 700, 900, 1100, 1300, 1500 and 1700 cycles, which have been designated 0, 1, 2, 4, 7 and 10 respectively. Frequencies 0 to 7 are used for digit codes and frequency 10 is used in combination with frequency 2 for the KP signal and with frequency 7 for the ST signal. The following chart indicates the combinations used:

Frequency & Designation	Digit Codes											
	0	1	2	3	4	5	6	7	8	9	KP	ST
1700 (10)											X	X
1500 (7)	X							X	X	X		X
1300 (4)	X				X	X	X					
1100 (2)			X	X			X			X	X	
900 (1)		X		X		X			X			
700 (0)		X	X		X			X				

X Frequency Used

It will be noted from the above chart that the additive system is used for determining the two frequencies required for all digits except 0, ST and KP signal. For digits 1 to 9 the two frequency designations are added together by using the smallest combination for the addition. For digit 0, the KP signal and the ST signal add up to 11, 12 and 17 respectively.

KP SIGNAL FREQUENCIES ON

When the receiving circuit IN repeat coil is cut through to a trunk or a keyset circuit at the beginning of a call, there is a brief period during which it may be exposed to speech or noise currents, which if it were necessary to receivedigit pulses, might cause false registrations in the associated sender circuit. To prevent this, the receiving circuit is normally held in a condition wherein digits cannot be registered until after it has been unlocked by the functioning of the KP signal. This signal is composed of a relatively long period of frequencies 2 and 10, which must be on for the required time without presence of the other frequencies 0, 1,4 and 7.

When the sender RV-1 relay operates and reverses the battery and ground, this is the signal to the No. 4 toll equipment, the No. 5 crossbar or the toll switchboard operator to start pulsing the frequencies.

VACUUM TUBES

L1 AND L2 LIMITER VACUUM TUBES

When the KP digit frequencies are present in the primary coils of the IN repeat coil, they are induced into the secondary coils causing the L1 and L2 limiter tubes to amplify and limit the KP signal.

The L1 and L2 vacuum tubes are arranged for push-pull amplification, the 54W retardation coil being used as an autotransformer. In push-pull amplification each tube works on one-half of the a-c cycle, the other tube at that instant being cutoff.

The KP signal as amplified by the L1 and L2 tubes enters the L condenser and network resistances N1, N2, N3, N4 and N5. This output of the limiter circuit is divided into two parts by the resistances N1 and N2. The voltage across the N2 resistance is delivered through the network N3 and N4 resistance to the six channel circuits while the voltage across the N1 resistance is applied through resistance N5 and the IN filter to the primary coil of the SP input transformer.

The compensating filter CF is provided to improve the characteristics of the 700 and the 1700 cycle filters by simulating the effect which would be produced by adjacent filters below and above them, respectively. This is necessary to prevent a beat frequency.

2 & 10 CHANNEL VACUUM TUBES

The channel tubes 2 and 10 function and decrease their plate current. Each plate circuit is connected through the bias winding of its associated polarized relay and the action is such that when signals are present, the plate currents in the tubes of the channels involved are decreased, thereby decreasing the current in the secondary or bias winding.

The control grids of the channel tubes in their static condition and for all practical purposes are at 0 potential with respect to the cathodes. When a signal is applied to their control grids, each time they swing positive, the action is such that the current attempts to increase in the plate circuit but before this can happen the tubes reach their saturation point. Reaching the saturation point means that the tubes are not conducting sufficient electrons to the plate to increase the current. When the control grids swing negative then the repelling effect of the electrons is such that the current is decreased in the plate circuit.

SIGNAL PRESENT CIRCUIT

The signal present circuit consisting of the IN filter, the SP input transformer, the SP vacuum tube and the SP relay, is for the purpose of indicating to the receiver circuit when there is a signal present within the range of 700 cycles to 1700 cycles and of sufficient magnitude to be locked in. It is also for the purpose of preventing duplicate registration of a digit when the incoming signal is prolonged.

SP

The SP relay operates due to the decrease of current in its secondary winding, caused by the action of the plate current of the SP tube. The action of the SP tube is the same as previously described for the channel tubes.

With no signal present both windings of the SP relay are energized. The primary winding is energized from ground on the T1 jack to battery on the FLT repeat coil. The secondary winding is energized by supplying the positive potential to the plate of the SP tube and the tubes internal action. Since the primary winding is poled for operate and the secondary winding is poled for release, the secondary overpowers the primary until the current is decreased on the plate of the SP tube.

The purpose of the SP retardation coil and the SP1 condenser is to reduce modulation products which would otherwise cause the SP relay to chatter. It also slows up the operate and release time of the relay by the charge and discharge of the SP1 condenser.

With the SP relay normal, the back contact is connecting a positive potential in parallel with a negative potential to the cathodes of the L1, L2 and SP tubes; the bias being more negative than positive and by this same circuit the L3 condenser is short-circuited. This holds the tubes to a definite limited output.

When the SP relay operates and removes this positive potential, the short circuit is removed from the L3 condenser at the same time which charges and continues to hold a positive bias in the parallel circuit on the cathodes. When the L3 condenser is charged to the potential of the battery on the FLT repeat coil, there will be no further current flow in this leg of the current. When this point is reached, the cathode bias on the L1, L2 and SP tubes becomes more negative, thus increasing their sensitivity. This will cause a rise in the volume limiter circuit which will be sufficiently gradual by the L3 condenser charging to prevent objectionable transients.

2 & 10

The operation of the SP relay connects ground to the primary windings of the 0, 1, 2, 4, 7 and 10 relays in series but only the 2 and 10 relays can operate because of the decrease in current in their secondary windings. The primary windings in series are poled in the operate direction. The circuit is traced from filtered battery on the FLT repeat coil to the primary winding of the 10 relay in series with the 7, 4, 2, 1 and 0 relays, through the T1 jack, CH1 resistance, over the L lead to the sender, break contacts OE and ST relays, operated contacts RV-1 relay, break contacts TN and TO relays over J lead to receiving circuit, break contacts CK-1 relay, make contacts of SP relay to ground.

KP-1

The KP-1 relay is made slow operate by condenser timing for the purpose of insuring that the KP signal is present for its proper duration. The primary is the operate winding and the secondary the release winding. By the operation of the 2 and 10 channel relays, direct ground is disconnected from the secondary winding, at the same time the short circuit is removed from the KP1 and KP2 condensers. Battery through the secondary winding then charges the KP1 and KP2 condensers, this charging current holding the KP-1 relay on its back contact.

As the condensers become charged, this current decreases until the energy in the primary winding is greater than the secondary winding, thus causing the KP-1 relay to operate. The time interval in condenser timing is proportional to the capacity of the condensers being charged. In this case, the condenser capacity is approximately 4.32 M.F. which gives a time value of 48 milliseconds before the KP-1 relay operates.

It should be noted that on the KP signal only the 2 and 10 relays, both operated, can remove the short circuit from the KP1 and KP2 condensers.

As previously stated, it is necessary that frequencies 2 and 10 be received for a definite length of time without frequencies 0, 1, 4 and 7 being present if the receiver is to be unlocked. If an impulse of one or more of these frequencies should appear at the same time as the KP signal, the corresponding channel relay or relays will operate and apply a short circuiting ground to the KP1 and KP2 condensers. This will take place through the back contacts of the KP-2 and KP-3 relays. This will restore the full bias current to the secondary winding of the KP-1 relay releasing it immediately and discharging the KP1 and KP2 condensers rapidly. This restores the condenser timing in preparation for a new timing cycle, with the net result that the receiver remains locked until frequencies 2 and 10 appear by themselves for the necessary length of time.

KP SIGNAL FREQUENCIES OFF

When the KP signal is disconnected from the fundamental circuit, the L1, L2, SP, 2 and 10 tubes all return to normal. This means that their control grid bias and plate voltage return to their normal values. This will cause the plate current in the SP, 2 and 10 tubes to increase and place the normal bias on the secondary windings of the SP, 2 and 10 relays.

KP-2 & KP-3

The KP-2 and KP-3 relays will operate with the KP-1 relay operated and the release of either the 2 or 10 relay. While the signal present circuit causes the operation of the KP-1 relay, the 2 or 10 relay must return to normal in order to have an operating circuit for the KP-2 and KP-3 relays.

With the KP-2 and KP-3 relays operated, the receiving circuit is now unlocked. This is accomplished by the removal of ground from the OC to 10C resistances, allowing the ground on the back contacts of the 0, 1, 4 and 7 relays to have control and the ground on the back contacts of the 2 and 10 relays to be connected to the 2C and 10C resistances. The grounds on the back contacts of all channel relays are now short-circuiting the primary windings of the CK-1, CK-2 and CK-3 relays.

0 TO 10 TERTIARY WINDINGS

The tertiary windings of the 0 to 10 relays are wired in series and are energized from the filtered battery on the FLT repeat coil to ground on the make contacts of the KP-3 relay. These windings supply a small additional bias to the 0 to 10 relays when the receiver is prepared to receive the numerical digits, but not when it is waiting for the KP signal. This bias is necessary to insure the release of relays after they have been locked up on digit codes as described later but is not needed when the KP signal is being received because by omitting this circuit a small increase in sensitivity is obtained.

KP-1 RELEASE

The top 4 and 5 contacts of the KP-2 relay causes the secondary winding of the KP-1 relay to be energized and the KP1 and KP2 condensers to be short-circuited. This causes the KP-1 relay to release and the discharge of the condensers but it does not interfere with the unlocking of the receiver because the KP-2 and KP-3 relays have locked up. The purpose of this arrangement is to make sure that the timing circuit is normal and ready to give a complete timing cycle on the next call without having to place any requirements on the open interval required between the calls.

A sequence adjustment is made on the contacts of the KP-2 relay to insure that the locking circuit, the top 10 and 11 contacts make ahead of the top 4 and 5 contacts that release the KP-1 relay.

The KP3 resistance is provided to insure that relay KP-1 shall always go to its back contact when the receiver is idle. If it were omitted, the removal of battery from the BAT2 lead during the time between the breaking of the back contact of relay KP-1 and the operation of relays KP-2 and KP-3, as might occur in an abandoned call, would leave the circuit blocked, since the condensers would be charged and there would be no current flowing in the secondary winding of relay KP-1 to release it.

REGISTRATION

The receiving circuit is now ready to receive the digit frequencies for the office code and numerical digits thousands, hundreds, tens, units and stations, which follow immediately after the KP signal. With the receiver unlocked and the KP-2 and KP-3 relays operated, the 0, 1, 2, 4 and 7 leads from the make contacts of their associated channel relays are cut through to the make contacts of the M.F. sender AA relay to the windings of the A-0, A-1, A-2, A-4 and A-7 register relays. Each digit is registered by the grounding of two and only two of the five leads 0 to 7 from the receiver.

SIGNAL COUNTING AND SCREEN GRID LOCK

When the frequencies are connected for a digit of the office code or the called number, the receiving circuit functions the same as already described for the action of the L1, L2, SP and channel tubes. But since the receiver is now unlocked, there is a signal counting circuit consisting of the CK-1, CK-2 and CK-3 relays used to check for the proper number of frequencies and which incorporated a feature known as the screen grid lock.

When the two channel relays operate, the digit is locked in. This locking action is obtained in a rather unusual way by means of the vacuum tube circuits. When a channel relay operates, after the plate current flowing through its bias winding has been decreased sufficiently by the incoming signal, it removes its part of the short circuit on the CK-1, CK-2 and CK-3 relays, and connects the screen grid of its associated tube to a potentiometer which supplies a much lower voltage than normal. This is accomplished by the removal of the grounds on the back contacts of the two channel relays to the screen grid of the associated vacuum tubes (+ voltage with respect to the cathode of the tube) and substitution of a reduced voltage obtained from the potentiometer made up of the associated resistances 0B and 0C to 7B and 7C, and the primary windings of the CK-1, CK-2 and CK-3 relays.

This causes the plate current on each of the two channel tubes involved to decrease below 3 mills and remain there, effectively locking up their associated relays until the operate windings (primary) are de-energized. The circuit remains in this condition even though the M.F. pulses from the originating end have ceased.

CK-1, CK-2 & CK-3

The signal counting circuit is provided for the purpose of recognizing that a correct digit signal, consisting of two frequencies and only two is being received after the circuit has been unlocked by the KP signal, while if an extraneous frequency should appear and operate one or more additional channel relays, a reorder signal is given as described later assuming that the correct signal has been received operating the two channel relays. These relays by removing ground from their back contacts open up their individual parts of the short circuit on the CK-1, CK-2 and CK-3 relays. This allows current to flow through the primary windings of the CK-1, CK-2 and CK-3 relays.

The CK-3 relay does not operate in the series circuit as long as a combination of only two frequencies are received per digit. Should one or more additional frequencies be received, the removal of more than two of the grounds on the back contacts of the channel relays changes the balance in the potentiometer circuit, causing the CK-3 relay to operate. The CK-3 relay in operating grounds the RO lead for a reorder as described later. The CK-1, CK-2 and CK-3 relays serve to check the incoming signals and to tell the sender whether it should register a digit in accordance with the grounds on the 0 to 7 leads.

None of the CK-1, CK-2 or CK-3 relays will operate when only one channel relay is operated.

The make contacts of the CK-1 relay connects ground through the CH2 resistance, over the J lead to the sender, break contacts TO and TN relays, make contacts RV-1 relay, break contacts ST and OE relays, over the L lead to the receiver, CH1 resistance, to the primary windings of the channel relays, to hold these windings energized, in turn holding operated the two relays. The ground on the CK-1 relay replaces the ground from the operated contacts of the SP relay.

The purpose of adding the CH2 resistance to this circuit is to reduce the sensitivity of the channel relays somewhat, after two of them have operated, as a protective measure to reduce the likelihood of operating a third channel.

LOCKING IN REGISTRATION

The sender relays AA, AB, BA, BB, CA, CB, THA, THB, etc., are used as a walking circuit to transfer the receiving circuit registration leads from digit to digit as the call progresses. These relays are controlled by the operation and release of the CK-2 relay. Each time the CK-2 relay operates, it locks in the A relay and short circuits the B relay of the group causing the B relay to release. Then at the completion of the digit, the CK-2 relay releases, releasing the A relay. The release of the A relay transfers the registration leads 0, 1, 2, 4 and 7 to the next group of register relays.

As the A relay releases after each digit registration, the make-before-break contacts top No. 1, No. 2 and No. 3, provide a locking circuit for the register relays. The No. 1 and No. 3 contacts lock in the register relays to off-normal ground at the ON-1 relay.

The ground from the make contacts of relay CK-2 insures that the digit will be registered correctly on short pulses due to the fact that the CK-2 relay is held up by the locking of the channel relays as already described, while the ground from the SP relay insures that these is no double registration in case the incoming signals are held on longer than the time actually required for registration. The signals must be present for at least 27 milliseconds.

CKA

The CKA relay is operated initially when the ON-3 relay operates and preceding each digit registration to provide a slight delay in closing the operating path for the TO relay. Thus, the CKA relay is slightly slow release to insure time for the receiver upon recognizing receipt of more than two frequencies to operate the CK-3 relay and ground the RO lead.

TO

The TO relay is marginal, operating only when two register relays have been operated and have closed their locking circuits. The battery through two or more secondary windings in parallel are closed by the B relay in the group of the walking circuit and the release of the CKA relay, are connected to the primary winding of the TO relay to ground on the break contacts of the CK-3 relay in the receiver circuit. In case one register relay only is operated, this locking circuit will not be closed and at the termination of the pulse, the operated register relay will release.

The TO relay receives its locking circuit from ground on the operated contacts of the CK-1 relay over the J lead.

The operation of the TO relay opens the operating circuit for the primary windings of the channel relays, which are now released by their tertiary windings. The disconnection of ground from the make contacts of one channel relay opens the screen grid lock.

CK-1 & CK-2 RELEASE

The release of either or both channel relays causes the release of the CK-1 and CK-2 relays. This is caused by ground being reapplied to the vacuum tube side of the corresponding OC to 7C resistances restoring the screen grid voltage to normal.

The release of the CK-1 relay opens the locking circuit for the TO relay but the operating circuit is not opened until the A relay in the walking circuit has released. When both of these circuits are opened the TO relay is released by its tertiary winding.

If at the time the CK-1 relay releases, if the digit signal is still on holding the SP relay operated, ground will be held on the J lead by the SP relay, holding the locking circuit on the TO relay and preventing the

J and L leads from being reconnected until the signal is off. The circuit is then ready for the next pair of digit frequencies.

REGISTRATION OF THREE-DIGIT OFFICE CODE

A-0 TO A-7 & AOA TO A7A

A 3-digit office code is registered on the A, B and C register relays. These codes are from 200 to 999, this being controlled by the fact that the alphabetical letters on the dial start in the second pull position of the dial. The A digit register relays A0 to A7 operate corresponding auxiliary relays AOA to A7A. These relays are necessary to gain additional switching contacts for grounding the proper combination of leads to the marker circuit and for P.C.I. pulses as described later.

It will be noted that the H lead closure from the receiving circuit for the A digit is different than other digits since it is closed to the AA relay by the prior operation of an A- register relay. This slight delay is compensated for by making the A0 to A7 register relays fast-operate permalloy relays.

The operated A-0 to A-7 register relays are indicated below for all combinations of frequencies received in the A digit and represent the same numbered combinations for all succeeding digit register relays:

Digit	Relays Operated
0	A-4 A-7
1	A-0 A-1
2	A-0 A-2
3	A-1 A-2
4	A-0 A-4
5	A-1 A-4
6	A-2 A-4
7	A-0 A-7
8	A-1 A-7
9	A-2 A-7

AB-5

The AB-5 relay which is operated by the ON-1 relay is for the purpose of indicating to the marker whether the A digit of the office code is above 5 or below 5. The A register relays A0 to A7 by their combinations for digits 5 to 9 cause the AB-5 relay to release. On digits 2 to 4 the operating circuit for the AB-5 relay is not opened or a holding circuit is provided.

AL-1 & AL-2

The AL-1 relay is operated by one of the AOA to A4A relays when the A digit is registered. The AL-1 relay in operating causes the release of any time measure relays which might be operated, and disconnects ground from the TM2 interrupter. This ends the first timing period as described later, which started when the ON-1 relay operated.

When the TM- relays have released, a path is closed for the operation of the AL-2 relay. With the AL-2 relay operated, ground is connected to the TM2 interrupter for a new timing cycle as described later.

B-0 TO B-7 & BB-5

The B digit is registered on the B-0 to B-7 register relays. The BB-5 relay is operated from the ON-1 relay and may release or remain operated depending upon the digit registered. The BB-5 relay is for the purpose of indicating whether the B digit is above 5 or below 5. On digits 0 to 4 the operating path is not opened or a holding path is provided. For digits 5 to 9 the BB-5 relay is released by the combination of B- relays operated.

C-0 TO C-5 & CL

The C digit is registered on the C-0 to C-7 register relays. The operation of any one of the C-0 to C-4 relays which will be included in any combination of the C digit, operates the CL relay. The CL relay is for the purpose of indicating that the complete office code has been registered and that the call has progressed to the point of selecting a marker as described later.

REGISTRATION OF SERVICE CODES

11A & 11A'

Service codes of 3-digit numbers from 100 to 109 or 120 to 199 are used for operating purposes within the jurisdiction of traffic between central offices and controlled by operators at toll switchboards. These serivce codes are not usable for subscriber dialing. For the present, service codes will be used as a 3-digit operator code for informational purposes and the present design is so arranged that no numerical digits are to be received after a service code.

When a service code is received, the initial 1 is registered by the operation of the 11A and 11A' relays; the second and third digits are registered on the A and B registers. The A-0 and A-1 register relays, when operated, provide no operating path for the TO relay from their locking windings. In addition, the H ground from the receiving circuit is not connected through to advance the walking circuit by shunting down the AB relays. Instead, a path through the operated A-0 and A-1 relays is closed to operate the 11A relay, which locks and short-circuits the 11A' relay.

The 11A relay operated, connects battery through 875 ohms to operate the TO relay, this resistance being equivalent to two register relay locking windings in parallel. The operation of the TO relay opens the J and L leads to the receiving circuit which allows the channel relays to release and they in turn release the sender A-0 and A-1 relays. The release of relays A-0 and A-1 allows the TO relay to release and opens the short-circuit on the 11A' relay, which operates.

The second digit of service code is any digit from 0 to 9, except "one." The registration of this digit is now recorded on the A- register relays, the operation being the same as explained for the A digit in three-digit office codes. The walking circuit is then advanced to the B digit register relays, on which the C digit of the service code is recorded.

This difference in operation on service codes is a result of the fact that only with the combination of the A-0 and A-1 pair of register relays is the H lead ground not closed through, and there is no locking path for these two relays when they are operated together.

REGISTRATION OF NUMERICAL DIGITS

After a three-digit office code, either four or five numerical digit frequencies will follow. These digits are recorded on the TH-, H-, T-, U- and ST- register relays.

TH-0 TO TH-7, TH-0A TO TH-7A & THL

The operation of one of the TH-0 to TH-4 register relays which happens in any thousands digits combination causes the THL relay to operate. The operation of the THL is for the purpose of indicating to the M.F. sender whether it can go ahead with certain selections to the distant office as explained later.

The TH-0A to TH-7A relays are auxiliary thousands relays operated for the purpose of gaining additional contacts for selections and P.C.I. pulses.

H-0 TO H-7, H-7A, IGH & HL

The operation of one of the H-0 to H-4 register relays, which are included in any hundreds digits combination, causes the HL relay to operate. The operation of the HL relay is for the purpose of indicating to the M.F. sender that it can go ahead with certain selections because the hundreds digits is now recorded, this information being explained later.

The H-7A register relay is an auxiliary relay to the H-7 register relay to gain additional contacts for P.C.I. pulsing. The H-7A relay will operate for hundreds digits 0 and 7 to 9. This relay also aids in the operation of the IGH relay as described in the following paragraph.

The IGH relay operates on any of the combinations of hundreds register relays operated for digits 5 to 9.

T-0 TO T-7 & TA-5

The combination of T-0 to T-7 relays operated for tens digits 5 to 9 causes the operation of the TA-5 relay.

U-0 TO U-7 & UL

When one of the U-0, U-1, U-4 or U-7 register relays operate for units digits registration, the UL relay is operated.

ST-0 TO ST-7

When the number called is to a manual office having numbers over 10,000 or party lines, a stations digits will be received and recorded on the ST-0 to ST-7 register relays.

START SIGNAL FREQUENCIES

After a service code, a three-digit operator's code or a three-digit office code and number, as the case may be, a start signal is sent from the originating office as an indication that frequency pulsing is completed, The start signal consists of frequencies 7 and 10.

ST

The start pulse causes the operation of the ST relay when it is received following the registration of the C digit for a service code or a three-digit operator's code, following the units digit for four-digit numbers, or following the station digit for five-digit or party-line numbers.

Ground connected to the 7 lead by the receiving circuit causes the C-7 relay to operate after a service code of the TH-7 relay after a three-digit operator's code, or the ST-7 relay after a four-digit number only. The 7 lead has no function if the start pulse is received after a station digit registration.

Ground connected to the 10 lead by the receiving circuit after a service code causes the operation of the ST relay as follows: ground on 10 lead, break contacts CL relay, make contacts 11A' and C-7 relays to winding of ST relay. The 10 lead ground connected after a three-digit operator's code causes the ST relay to operate through the break contacts of the THL relay and the make contacts of the TH-7 relay. The start signal following four-digit numbers, five-digit numbers or party-line numbers, the ST relay is operated through the make contacts of the UL relay, the UL relay being controlled by the units digit only.

The J and L leads to the receiving circuit will not be opened by the TO relay since only one register relay operates for three of these conditions, therefore, the channel relays are held operated. The J and L leads are connected through a set of break contacts on the ST relay so that upon its operation during the start signal it allows the receiver circuit channel relays to release, in turn releasing the CK-1 and CK-2 relays, the CK-2 relay operating the sender CKA relay.

The walking circuit relays CA and CB, THA and THB, SA and SK, whichever are involved during the registration of the start signal will function the same as other digits when ground is connected and disconnected from the H lead by the receiving circuit.

COMMUNICATION WITH MARKER

Each M.F. sender circuit is wired to a marker connector circuit by about 56 individual leads. The function of the connector circuit is to connect the sender to a marker, which in turn,receives the code dialed, class of service and tandem trunk link frame information and then receives back all the necessary information for the sender to make its selections.

DST

The DST relay operates when the CL relay operates indicating that the three digits of the office code are recorded on the A, C and C register relays. The DST relay is the decoding start relay and when operated connects battery to the ST and CBS leads to the marker connector circuit. This causes a tandem marker to be selected and connected through to the M.F. sender.

The closure of the top No. 3 and No. 5 contacts on the DST relay connects battery to the windings of the S-1 to S-7 relays, the 0 to 6 counting relays, the RC relay and the FO-3 relay. This causes the operation of the RC relay, which in turn, operates the FO-3 relay.

When a service code is recorded in the 11A, 11A', A- and B- register relays, the ST relay operating immediately after by the start signal causes the operation of the DST relay. Under this condition the CL relay receives no operating path since only the C-7 relay operates from the start signal and this relay has no operating ground for the CL relay.

INFORMATION FROM SENDER TO MARKER

The M.F. sender, by a combination of grounded leads, transfers to the marker the number of the trunk link frame, the class of trunk, the office code and whether this is a first, second or third trial call.

The information transmitted to the marker for the trunk frame number consists of grounding one lead and only one in the set 0 to 4, and one lead in the set A5 or B5, the A5 and B5 standing for above 5 or below 5 in a group of 10. In addition, one of leads F00 or F10 is grounded to indicate a frame below 10 or above 10, respectively.

FRAME	LEADS GROUNDED		
0	F0	FB5	F00
1	F1	FB5	F00
2	F2	FB5	F00
3	F3	FB5	F00
4	F4	FB5	F00
5	F0	FA5	F00
6	F1	FA5	F00
7	F2	FA5	F00
8	F3	FA5	F00
9	F4	FA5	F00
10	F0	FB5	F10
11	F1	FB5	F10
12	F2	FB5	F10
13	F3	FB5	F10
14	F4	FB5	F10
15	F0	FA5	F10
16	F1	FA5	F10
17	F2	FA5	F10
18	F3	FA5	F10
19	F4	FA5	F10

Lead MF is grounded to the marker to indicate that a multi-frequency sender is connected.

The class of service leads CS-0 to CS-6 are grounded to the marker connector circuit in accordance with the cross-connections made between the CS-0 to CS-6 punchings and the CL- and CG- punchings 0 to 9.

The A, B and C register relays operated for a three-digit office code or a three-digit operator's code causes a combination of B-, D- and G- leads, respectively, to be grounded to the marker connector, as indicated below:

A DIGIT	LEADS
2	B2 - BB5
3	B3 - BB5
4	B4 - BB5
5	B0 - BA5
6	B1 - BA5
7	B2 - BA5
8	B3 - BA5
9	B4 - BA5

B DIGIT	LEADS
0	D0 - DB5
1	D1 - DB5
2	D2 - DB5
3	D3 - DB5
4	D4 - DB5
5	D0 - DA5
6	D1 - DA5
7	D2 - DA5
8	D3 - DA5
9	D4 - DA5

C DIGIT	LEADS
0	G0 - GB5
1	G1 - GB5
2	G2 - GB5
3	G3 - GB5
4	G4 - GB5
5	G0 - GA5
6	G1 - GA5
7	G2 - GA5
8	G3 - GA5
9	G4 - GA5

TXA, TXB & TXC

When a service code is recorded on the 11A and 11A', A-0 to A-7 and B-0 to B-7 register relays there is a transfer in grounded leads to the marker connector circuit. When the DST relay operates with the 11A relay operated, a path is closed to operate the TXA, TXB and TXC relays in parallel. The TXA relay transfers the contacts of the A-0A to A-7A relays from the B- to the D- leads. The TXB relay transfers the contacts of the B-0 to B-7 relays from the D- to the G- leads and the TXC relay opens the G- leads from the C-0 to C-7 relays. The B-1 and BB-5 leads are grounded by the operated 11A' relay indicating to the marker that this is a service code.

FIRST TRIAL CALL

On a first trial call the sender TR-2 and TR-3 relays are released, thereby, connecting ground to the TR1 lead to indicate to the marker that this is a first trial call.

INFORMATION FROM MARKER TO SENDER

The marker transmits selection information to the sender by grounding a selection of leads to operate the corresponding designated selection register relays in the sender. These relays may be released and reoperated in a different pattern if the marker should be unable to find an idle trunk and an idle path to it, and reroutes the call. The selection relays do not lock up until relay DRL is operated by the marker. Even after they are locked up, they may be released for a second or third trial call by the release of the DST relay as explained later. The sender relays operated at this time are given in the following sections, as applying to all classes of calls.

OFFICE BRUSH & OFFICE GROUP

A call to a crossbar, panel or manual office may be routed through a distant office selector, the OB and OG relays being required for directing the office selector. A call may be routed to another crossbar tandem office in which case the OB and OG relays will be required as a code to this second tandem point. A call may be routed to a step-by-step office, in which the OG relays are used for a sixth digit.

When a call is routed to another crossbar tandem office, it is necessary to indicate a high and low office brush selection. When used for office selections or a tandem code with high and low condition, the OB and OG relays are operated as follows:

OFFICE BRUSH	RELAYS OPERATED
0	None
1	OB-1
2	OB-2
3	OB-1, OB-2
4	OB-4
5	OB-5
6	OB-5, OB-1
7	OB-5, OB-2
8	OB-5, OB-1, OB-2
9	OB-5, OB-4

OFFICE GROUP	RELAYS OPERATED
0	None
1	OG-1
2	OG-2
3	OG-1, OG-2
4	OG-4
5	OG-5
6	OG-5, OG-1
7	OG-5, OG-2
8	OG-5, OG-1, OG-2
9	OG-5, OG-4

When office group relays are used for a sixth digit on a step-by-step call and which may be any digit from 0 to 9, the marker operates the OG-relays as follows:

OFFICE GROUP	RELAYS OPERATED
1	None
2	OG-1
3	OG-2
4	OG-1, OG-2
5	OG-4
6	OG-5
7	OG-5, OG-1
8	OG-5, OG-2
9	OG-5, OG-1, OG-2
0	OG-5, OG-4

SKIP OFFICE

In case there is no office selections required in the route, the skip office relay is operated by the marker but none of the OB and OG relays are operated. The SO relay causes the sender to skip the functions of office trunk test, office brush selection and office group selection.

CLASS OF CALL INFORMATION

The class of call information is indicated by the marker operating the following combination of relays:

RELAYS	CLASS OF CALL
None	Full selector to panel office
XB	Full selector to crossbar office
CI, TCI	PCI tandem - 7 or 8 digit
CI, XB, TCI	PCI direct
CI, OD, TCI	PCI tandem - 3-digit
OD, TCI	Overflow, vacant codes or straightforward routing - does not wait for numerical digits
SSA, SO	Four-digit SXS class (loop pulsing A)
SSB, SO	Four-digit SXS class (loop pulsing B)
SSA, SSB, SO	Four-digit SXS class (bat. & grd. pulsing)
SSA, IG5, SO	Five-digit SXS class (loop pulsing A)
SSB, IG5, SO	Five-digit SXS class (loop pulsing B)
SSA, SSB, IG5, SO	Five-digit SXS class (bat. & grd. pulsing)
SSA	Six-digit SXS class (loop pulsing A)
SSB	Six-digit SXS class (loop pulsing B)
SSA, SSB	Six-digit SXS class (bat. & grd. pulsing)

SXS = Step-by-step offices.

Loop pulsing A is used for pulsing into:

1. Local switch train
2. AB toll train
3. Incoming repeaters

Loop pulsing B is used for pulsing into:

1. Local repeater circuits

Battery and ground pulsing is used for pulsing into:

1. Local switch train
2. AB toll train

COMPENSATING RESISTANCE

The compensating resistance used in the M.F. sender for office selections is determined by the CR-4 relay. With the relay released, 900 ohms office compensating resistance is provided in the fundamental circuit and with the relay operated, no resistance is included.

900 ohms	CR-4 Released
0 ohms	CR-4 Operated

The compensating resistance used for incoming trunk test and subsequent selections on crossbar, panel and call indicator calls is indicated by the combination of CR-1 and CR-2 relays operated. Compensating resistance is not required on step-by-step calls.

Resistance	Relays Operated
900 ohms	CR-1, CR-2
600 ohms	CR-2
300 ohms	CR-1
0 ohms	None

CR-5

The CR-5 relay is operated on all calls over trunk groups containing some trunks to non-repeating ground cutoff panel incoming selectors. It serves to substitute relay MTG for TG to close a cable discharge circuit before final brush selection and to close an auxiliary path for operating the 0, BO and FO counting relays through a late making contact on the IA relay, in case a very short reverse battery pulse is received in incoming advance.

IG5

If multi-office terminating units are reached over common trunk groups, the marker will operate the IG5 relay for one of the offices and this relay will be normal for the other. The IG5 relay, when operated, adds five to the incoming group selection.

SD1

The SD1 relay is operated on all calls except those calls to manual offices having some lines with five-digit numbers, that is, numbers over 9999.

TW

The TW relay is operated by the marker when the call is to be routed through a distant office selector for the purpose of extending the timing out period for stuck sender. It is operated when the call is routed through a crossbar tandem office using a revertive pulse sender to extend the timing out period for stuck sender and to avoid the possibility of a wipe-out causing a stuck sender at the distant tandem office. It is operated on calls to ADCI equipment (automatic display call indicated positions) to extend the timing out period for stuck sender and to avoid a trunk lockup condition if a wipe-out occurs just as the ADCI position is seized.

RELEASE OF MARKER CONNECTOR

After the marker has operated the required selection register relays, it proceeds to select an idle trunk to a distant two-wire office selector or to the called office, after which it connects ground to the DC lead of the sender in order to retain control of the sender after the marker connector is released.

DC

The DC relay is operated in the M.F. sender by the connection of ground to the DC lead. The operating ground for the DC relay is extended through its operated contacts to the DC lead of the sender link through the sender link crosspoints to the trunk and operates the trunk F relay. This same ground is again extended over the LC lead to the trunk link and connector circuit, after the F relay operates, to the marker operating a relay as a check that this ground was received by the sender and trunk satisfactorily. The marker then connects a ground back over the LC lead to trunk and over the sender link DC lead to the sender, locking in the trunk F relay and the sender DC relay. When this is accomplished, the marker connector can be released with the marker still controlling the sender by way of the trunk.

PREPARATION FOR SELECTIONS

SOAKING STEPPER RELAY (STP)

Whenever the DC relay is operated, it sends a current through the winding of the STP relay to soak it in the direction of normal operation, and to remove any residual magnetism due to any preceding reverse battery.

DRL

The marker causes the sender to release the marker connector by connecting ground to the RL lead, this causing the operation of the DRL relay. The DRL relay disconnects battery from the ST lead, allowing the marker connector to release.

S-3 OR S-6

The operation of the DRL relay causes the operation of either the S-3 or S-6 selection relay. If the SO relay is normal, indicating that office selections are to be made, the S-3 relay operates at this time so that the sender will start its functions at office test. If the SO relay is operated, the S-6 relay operates so that the sender will start at trunk test. The S-3 or S-6 relay, in operating, causes the S-3' or S-6' relay, respectively, to be short-circuited until the DC relay is released by the marker.

INDICATION THAT REGISTRATION IS COMPLETED

The numerical registration when required for a call, in all probabilities, will not be completed when the DRL relay operates for connector release. It is also possible that the sender may start its selections at the distant office before the numerical registration is completed. For this reason there are stop-gaps provided in the sender to prevent it from going ahead with certain operations until the necessary information is present. To illustrate this point, the UL relay operates upon registration of the units digit, but whether a fifth numerical digit (stations) is to be received can only be determined by the marker decoding and the information returned to the sender. In addition, the ST relay in operating indicates that the start signal has been received but it is being received after three digits or after seven digits. The marker for this reason operates the OD relay to indicate when there are no numerical digits to be received. Also, by the operation of the XB or SD1 relay, or keeping them normal, provides a path to operate the C and C' relays or the STA and STA' relays or the STB and STB' relays.

C & C', STA & STA', STB & STB'

On calls to crossbar central offices or to manual offices direct, the marker operates the XB relay. This relay operated on these types of calls causes the operation of the C and C' relays with the DRL relay operated on connector release and the ST relay operated for the start signal, ground being supplied at the operated contacts of the ST relay.

When the C relay operates on these calls, it closes a path to operate the STB and STB' or the STA and STA' relays. On crossbar calls the STB and STB' relays operate. This path is traced from battery on the winding of the STB relay in series with STB', bread contacts ST-0, ST-1, ST-2 and ST-4 relays, break contacts SS-5 relay, make contacts UL, C, DRL and ST relays to ground. On PCI direct calls the STB and STB' relays operate if the office has no numbers over 9999, the SD1 relay being operated for these calls.

On PCI direct calls to office having numbers over 9999, the SD1 relay is normal and the STB and STB' relays or the STA and STA' relays may operate. If the number begins with 1 in the thousands and 0 in the hundreds, and the tens digit is below 5, the STA and STA' relays operate. This path is from battery winding STA relay in series with STA', break contacts TA-5 relay, make contacts H-7, H-4, TH1A and TH0A relays, break contacts SD1 relay, through make contacts of any combination of ST-0 to ST-7 relays, break contacts SS-5 relay, make contacts UL, C, DRL and ST relays to ground. If the number begins with 1 and 0, but the hundreds digit is 5 or over, the STB and STB' relays operate because in this case the TA-5 relay is operated. On numbers with thousands digit 0 or 2 to 9, the STB and STB' relays operate independent of the TA-5 relay.

On calls to panel central offices or when a service code is received, due to the XB relay being normal, the STB and STB' relays operate. The path on panel calls is from battery winding of STB relay in series with STB', break contacts ST-0, ST-1, ST-4, ST-2 and SS-5 relays, make contacts UL relay, break contacts XB relay, make contacts DRL and ST relays to ground. The path for a service code call is from battery winding of STB relay in series with STB' make contacts OD, break contacts XB, make contacts of DRL and ST to off-normal ground.

STC

The STC relay operates on all calls when the STA or STB' relay is operated and indicates when the full registration of the call is completed. Its function is to stop the second cycle of timing by operating the UL-1 relay, which causes all operated timing relays to release. When all timing relays are released, a path is closed to operate the UL-2 relay, which starts a new cycle of timing.

MARKER RELEASE

When the marker has completed its functions, it removes ground from the DC lead, by way of the trunk link and connector circuit, releasing the sender

DC relay. Release of the DC relay permits the sender to advance to either office test or trunk test, depending upon which of the two relays S-3 or S-6 is operated. The shunt that prevents the operation of the S-3' or S-6' relays is removed when the DC relay releases.

CLASSES OF CALLS

There are two full selector classes to panel and crossbar offices, respectively, this sender being arranged to control existing panel selectors in the same manner as a panel or crossbar subscriber's sender controls them, and to transfer the number crossbar terminating equipment using the same means.

When the call includes a two-wire office selector, the battery and ground for office test is furnished from that point and the tandem sender is satisfied by commutator pulses. There are three distinct functions performed at this point by the tandem sender as follows:

Office Test
Office Brush Selection
Office Group Selection

When the call is to terminate in a panel central office, the incoming and final selectors at that point furnish the battery and ground for trunk test and the associated selections, and the reverse battery signal known as incoming advance after selections are completed. There are seven distinct functions performed at this point by the tandem sender, as follows:

Trunk Test
Incoming Brush Selection
Incoming Group Selection
Final Brush Selection
Final Tens Selection
Final Units Selection
Incoming Advance

On a call to a crossbar office a terminating sender receives the number on the same basis as listed above for a panel call, the battery and ground being supplied from that point by this crossbar sender. The terminating sender sends revertive ground pulses to satisfy the tandem sender during the selections.

PROGRESS OF THE SELECTION SEQUENCE

The selection relays S-1 and S-1' to S-6 and S-6' and relays FS-1, FS-2 and FS-3 are used to make the proper connections in the tandem sender in a definite order as the sender progresses through its successive selections and trunk tests. On a full selector call to panel or crossbar these relays are operated as follows for the several stages:

STAGE OF CALL	RELAYS OPERATED
Office Test	S-3, S-3'
Office Brush Selection	S-4, S-4'
Office Group Selection	S-5, S-5'
Trunk Test	S-6, S-6'
Incoming Brush Selection	S-1, S-1', FS-1, FS-2
Incoming Group Selection	S-2, S-2', FS-1, FS-2
Final Brush Selection	S-3, S-3', FS-1, FS-2
Final Tens Selection	S-4, S-4', FS-1, FS-2, FS-3
Final Units Selection	S-5, S-5', FS-1, FS-2, FS-3
Incoming Advance	S-6, S-6', FS-1, FS-2, FS-3

If office selections are skipped, the first three stages are omitted and trunk test becomes the first stage with the S-6 and S-6' relays operated.

OFFICE SELECTIONS

OFFICE TEST

If office selections are to be made, the S-3 and S-3' relays are operated, as previously described. Operation of the S-3' and FO-3 relay causes the tandem sender TG or MTG relay to operate.

The TG or MTG relay is used for office test to determine that a normal trunk has been selected which is in condition for use. The FT and FR leads are closed at this time through the tandem sender link, tandem trunk, trunk link frame and office link frame to the outgoing trunk to the office selector circuit. The battery and ground to operate the TG or MTG relay are furnished at the tip and ring, respectively, of the office circuit, the battery being applied through the winding of the office circuit.L relay.

The CR-5 relay operated or left normal by the marker determines which trunk guard relay is used. Either one may be used for office test, the requirement being based on the incoming trunk group through which the call is to be routed. If the incoming trunk group includes any trunks to non-repeating ground cutoff incoming selectors, the marker will have operated the CR-5 relay and the MTG relay will be used for office test and trunk test. Otherwise the CR-5 relay will be normal and the TG relay will be used.

The path for operating the TG or MTG relay is traced through contacts of the CR-1 and CR-2 selection register relays, operated or left normal by the marker, and through sufficient resistance to increase the trunk resistance to a minimum of 900 ohms. The fundamental circuit for office brush and group selections also includes this resistance. This feature is provided to protect the fundamental relays against too heavy a current.

With the S-6 relay normal at this period of the call, the primary and tertiary windings of the OF relay are short-circuited in series and are not included in the fundamental circuit, also in parallel, the S-3 relay operated is short-circuiting the primary winding of the OF relay.

TG OR MTG

The path for operating the TG or MTG relay is traced from FT lead, break contacts of FTT, AV-2 and AV, make contacts FO-3, break contacts FO-2, make contacts S-3, break contacts FS-1, winding of either TG or MTG relay, break or make contacts of CR-5, break contacts OP-2, CI-2 and SS, through 14,500 ohms resistance, make contacts S-3', compensating resistance as required by transfer contacts of CR-4, break contacts AV and FTT relays, to the FR lead.

The 14,500 ohms resistance in the circuit prevents the office circuit L relay from operating, and permits the TG or MTG relay to operate only on 48-volt battery, thus preventing its operation if a trunk in talking position has been selected due to a trouble.

TG-2

The TG-2 relay operates the O, BO and FO relays in a series parallel circuit. The FO relay operates the S-4 relay which, in turn, operates the FO-1 and FO-2 relays. The FO-2 relay releases the FO-3 relay which opens the fundamental circuit releasing the TG or MTG relay. The office selector has not moved off-normal as yet because the sender has only tested for the 48-volt battery on the L relay at the office selector.

OFFICE BRUSH SELECTION

S-4 & S-4'

With the S-4 and S-4' selection relays operated and the FO-3 relay operated, the sender is ready to do office brush selection. The FO-3 relay closes the fundamental circuit and now causes the office selector circuit L relay to operate. The fundamental circuit now includes the OF and STP relays and the contacts of the BO relay.

It will be noted that the OF relay is a polarized relay and when included in the fundamental circuit, its polarity signs on the primary winding are connected positive to the FT lead and negative to the FR lead. This is not in the proper direction to operate the relay since there is battery on the FT lead during selections. Its purpose is to record a reverse battery (battery FR and ground FT) condition during any selection, this being an abnormal condition as described later.

The fundamental circuit for brush selection is traced from FT lead, break contacts FTT, AV-2 and AV, make contacts FO-3, break contacts FO-2, primary winding of OF relay in parallel with its tertiary winding, make contacts S-4', winding STP relay, break contacts BO, SS-3 and FS-2, make contacts S-4', compensating resistance as required by transfer contacts of CR-4, break contacts AV and FTT, to FR lead. The tertiary winding of the OF relay is non-inductive.

COUNTING RELAYS

Office brush selection is controlled by the OB selection register relays operated by the marker as required. When office brush selection is set-up for controlling an office selector, the counting relays required are within 0 to 4. But if the office selections are to be used as a code to another tandem office, then the brush selection can be 0 to 9. The 0 to 9 selection is based on indicating to a distant tandem office, a low five or high five brush selection. The marker in transmitting the information to the sender either operates the OB-5 relay or leaves it normal as a means of additional five sets of counting relays when required.

The numerals appearing in circles as indicated at the OB-2 and OB-4 selection register relays and any others appearing throughout the circuit drawing are assumed to be connected to the like numerals in the circles at the 1' to 4' counting relays.

Assuming that the brush selection is No. 4 and the OB-5 relay is normal, indicating a low five, the STP relay in closing its contacts operates the No. 4 counting relay as follows: ground on break contacts FS-3, make contacts STP, break contacts FS-3, make contacts OF-2, break contacts SS-1, No. 6' and No. 1' counting relays, break contacts FO-5, make contacts S-4', break contacts FS-2, break contacts OB-1 and OB-2, make contacts OB-4, break contacts No. 4 counting relay, winding of No. 4 counting relay to battery. The No. 4 counting relay, in operating, short-circuits the No. 4' relay until the stepper relay (STP) releases on the first pulse. When this takes place, the No. 4' relay operates and the counting relay circuit is transferred to the No. 3 counting relay which then operates over the same path as described above when the STP relay reoperates after the first pulse. This continues on each succeeding pulse until the No. 2' counting relay operates, then the path includes the make contacts of the RC relay to operat the No. 1 counting relay. When the No. 1' counting relay operates, its transfer contacts change the counting relay circuit to exclude FO-5, S-4', FS-2, OB-1, OB-2 and OB-4 relays. The STP relay ground is now closed through the break contacts FS-3, make contacts OF-2, break contacts SS-1 and No. 6', make contacts No. 1', break contacts FS-2, S-5 and OB-5 to winding of No. 0 counting relay to battery.

If the OB-5 relay is operated by the marker then instead of the No. 0 counting relay, operating after the No. 1 counter, an additional five sets of counting relays are added. The OB-5 relay operated connects the make contacts of the No. 1' counting relay to the No. 6 counting relay, instead of the No. 0 counter. Now the sender counts down the additional five sets and when the No. 6 counter operates, it releases the No. 4, No. 3 and No. 2 pairs, operated on the first cycle. When the No. 5 counter operates, it releases the RC relay. The RC relay released connects the make contacts of No. 2' counter to the No. 0 counter.

Operation of the office L relay at the beginning of office brush selection advances the office circuit and causes ground pulses to be impressed on the FT lead by the A commutator. These ground pulses alternately shunt the STP relay and permit it to reoperate, thus causing the prime and then the next counter to operate. The counting relay locks and holds the prime relay in series.

The number of pulses received is equal to the number of counting relay pairs included in the selection and is always one greater than the number of the counting relay at which the count starts. When the last ground pulse is received, shunting the STP relay down, the BO and FO relays operate in parallel. The BO opens the fundamental circuit, preventing reoperation of the STP relay, thus completing the selection as set by the marker.

The FO-3 relay in releasing unlocks the counting relays allowing them to release at the end of each selection.

FO

The operation and release of the FO relay causes the selection sequence relays to advance to the next selection. The S-5 and S-5' relays are operated for office group selection.

FO-1

The slow release FO-1 relay is used to increase the open period between fundamental closures by approximately .065 second, making the total open period from operation of the BO relay to operation of the FO-3 relay approximately .130 second. This feature is necessary only in certain selections involving panel selectors and not in any case in connection with crossbar terminating equipment.

This long delay is required to permit a panel selector to advance in any No. 0 selection which starts with the selector commutator already closed. This condition is obtained in the final frame with a combination of No. 4 brush and No. 0 tens. In these cases, the B commutator is left closed when brush selection is completed. Closure of the fundamental tens selection operates the L and STP relays and when the L relay contact closes, the STP relay is immediately shunted satisfying the sender. After that, the selector circuit has to advance its switch and raise its brush rod, breaking the commutator before it can advance for the next selection. A similar condition is encountered in final units selection on a call in which the units digit is zero.

In order to allow sufficient time for the selector to advance before the sender again closes the fundamental and thus prevent out-of-step conditions due to the above, the slow release FO-1 relay is employed in all cases after final brush and final tens selections. The long delay is not needed after office brush selection but is used in this case because the S-5 relay also operates after final tens selection where the delay is necessary.

OFFICE GROUP SELECTION

Office group selection follows immediately after office brush starting when the FO-3 relay operates with the S-5 and S-5' relays operated.

The STP relay sends 1 to 10 pulses to the counting relays in the same manner as described for office brush except that the OG-1, OG-2 and OG-4 relays are used for the selection of counting relays 0 to 4 and the OG-5 relay is used to split the counting relays when 5 to 9 is required.

FO-1

When office group selection is completed and the FO relay operates, it in turn operates the S-6 relay. When the FO relay releases, the S-6' relay operates. This releases the S-5 and S-5' relays, the S-5' relay releasing the FO-1 relay.

In order for the FO-1 to release, the thousands digit registration must be completed if the call is to a panel office and both the thousands and the hundreds digit registration must be completed if the call is to a crossbar office. In either case a path is closed to hold the FO-1 relay operated when the S-6 relay operates, in order to delay trunk test.

On a panel or crossbar call if the thousands digit registration has not been received, the THL relay will not be operated indicating a completed registration. In this case, the path for holding the FO-1 relay operated is traced from, battery winding of FO-1 relay, break contacts FS-1, make contacts S-6, break contacts SS, LR-2, THL, LR-2 and STC, to off-normal ground. Therefore, when the THL relay operates, it opens this holding circuit for the FO-1 allowing it to release and the sender to do trunk test.

On a crossbar call, if the hundreds digit registration has not been received, then the FO-1 relay receives a holding path in addition to the above due to the HL relay normal with the XB class relay operated. The path for this holding circuit is traced from, battery FO-1 relay, break contacts FS-1, make contacts S-6, break contacts SS and LR-2, make contacts SB, break contacts S-2, SS-3, LR-2, HL, LR-2 and STC, to off-normal ground.

S-6

The S-6 relay in operating removes the tertiary winding shunt from the primary of the OF relay, so that the full value of the primary winding may be included in trunk test.

SKIP OFFICE

If there is to be no office selections, the SO relay is operated by the marker. Then the operation and release of the DC relay by the marker operates the S-6 and S-6' relays for trunk test instead of operating the S-3 and S-3' relays for office test. The locking circuit for either pair of S- relays is provided by the DRL relay so that they will not remain locked up in case the marker in shifting from one trunk group to another first operates the SO relay and then releases it.

FULL SELECTOR CALL TO PANEL OR CROSSBAR

TRUNK TEST

The TG or MTG relay is used for trunk test to determine that a normal trunk has been selected which is in condition for use. The FT and FR leads are closed at this time through the tandem equipment, and through a distant office selector if used to the outgoing trunk to the called office. The battery and ground to operate the TG or MTG relay are furnished at the tip and ring, respectively, of a panel incoming selector or a crossbar incoming trunk in the called office. The 14,500-ohm resistance in the circuit prevents the advance of the terminating circuit until such time as the M.F. tandem sender is ready for selections, and it permits the TG or MTG relay to operate only on 48-volt battery, thus preventing its operation if a trunk in talking position has been selected due to a trouble.

As previously described, the CR-5 relay operated or left normal by the marker determines which trunk guard relay is used. If the incoming trunk group includes any trunks to non-repeating ground cutoff incoming selectors, the marker will have operated the CR-5 relay and the MTG relay will be used. Otherwise the CR-5 relay will be normal and the TG relay will be used.

The path for operating the TG or MTG relay is traced through contacts of the CR-1 and CR-2 selection register relays, operated or left normal by the marker, and through sufficient resistance to increase the trunk resistance to a minimum of 900 ohms. The fundamental circuits for incoming and final selections and incoming advance also include this resistance.

The fundamental circuit is closed when relays S-6 and FO-3 are operated. The S-6' operates upon the release of DC when the marker establishes a connection to an outgoing trunk, if the call is skip office. The FO-3 relay operates upon the release of the FO-1 and FO-2 relays. However, the FO-3 relay will delay trunk test if the THL or THL and HL relays are not operated, as already described.

TG OR MTG

The path for operating the TG or MTG relay for trunk test is traced from FT lead, break contacts FTT, AV-2 and AV, make contacts FO-3, break contacts FO-2, make contacts S-6, break contacts TCI and FS-1, winding of TG or MTG, make or break contacts CR-5, break contacts OP-2, CI-2 and SS, 14,500 ohms resistnace, break contacts TCI, make contacts S-6', compensating resistance as determined by transfer contacts of CR-1 and CR-2, break contacts AV and FTT to FR lead.

The 14,500 ohms resistance in trunk test prevents the line relay of the panel incoming selector or the crossbar incoming trunk from operating until the STP is included in the fundamental circuit and the tandem sender is otherwise ready to count pulses for incoming brush selection.

TG-2

The TG-2 relay operates the 0, BO and FO relays to end trunk test, the operation of the FO causing the S-1 relay to operate. This leads to the release of the FO-3 relay which opens the fundamental circuit releasing the TG relays. The FO then releases and operates the S-1' relay.

FS-1 & FS-2

The operation of the S-1' relay operates the FS-1 and FS-2 relays in parallel, the FS-1 locks and closes a holding circuit for the FS-2. These two relays, when operated, add additional features for incoming and final selections as described later.

The FS-1 relay, in operating at this time, recloses the tertiary winding shunt to the primary winding of the OF relay.

INCOMING BRUSH SELECTION

As previously stated, on full selector calls to a panel or crossbar office, the tandem sender translates the call number as recorded on the thousands, hundreds, tens and units register relays into five incoming and final selections. The sender is satisfied for these selections by commutator ground pulses from the panel incoming and final selectors or by revertive ground pulses from the crossbar terminating sender.

The incoming brush selection is controlled by the TH-0 to TH-7 register relays, the operated contacts on these relays closing a path to a particular counting relay, depending upon the thousands digit received. The path to operate the counting relay at which the count starts is similar to the path given for office brush selection, except that the S-1' relay operated closes it through the thousands register relays.

The following formulas may be used to determine at what counting relay the count starts for incoming and final selections for any number:

$$\text{Incoming Brush} = \frac{\text{Called Number}}{2000}$$

The called number is divided by 2000 because an incoming brush has access to 2000 lines. The remainder is disregarded for incoming brush but is used for other selections.

$$\text{Incoming Group} = \frac{\text{Remainder of Incoming Brush}}{500}$$

The divisor of 500 is used because an incoming group has access to 500 lines. The remainder of this operation is disregarded for incoming group but is used for other selections.

$$\text{Final Brush} = \frac{\text{Remainder of Incoming Group}}{100}$$

The divisor of 100 is used because a final brush has access to 100 lines.

Final Tens = Tens Digit

Final Units = Units Digit

When the STP relay operates, due to closure of the fundamental circuit, the terminating equipment also advances and returns ground pulses to the sender over the FT lead. These ground pulses cause the STP relay to release and reoperate, and the counting relays to operate in order as before.

For all incoming and final selections, the operated contacts of the SR-1 relay are included in the path from the operated contact of the No. 1' counting relay to the next pair to operate; which is always zero for incoming selections and final brush selection and may be either zero or six for final tens and final units as described later. The SR-1 relay contacts are included in this path so that, in case of a premature disconnection as described later, release of the SR-1 relay may cause an incoming or final telltale.

FO-2

The operation of the FS-1 relay changes the operating path of the FO-1 relay and makes it possible to operate either the FO-1 or the FO-2 relay, the XB relay controlling this feature. When the slow release feature of the FO-1 is not required the FO-2 relay is operated instead of the FO-1 relay.

FO-2

On calls to panel offices the FO-2 relay releases only if the hundreds digit has been dialed. Otherwise, incoming group selection is delayed by a path which holds the FO-2 relay through contacts of the SS-1, XB, FS-1, S-2, SS-3, LR-2, HL, LR-2 and STC relays.

INCOMING GROUP SELECTION

Incoming group selection is made with the S-2 and S-2' relays operated, starting when the FO-3 relay operates to close the fundamental circuit.

IGH

Incoming group selection is controlled by the combination of thousands and hundreds digit registration, the counting relay path being closed through by the S-2' relay operated. It was previously stated that the IGH relay operates when the hundreds digit registration is 5 to 9. If the thousands digit is an even number and the hundreds digit is 0 to 4, the incoming group selection will start at the No. 0 counting relay. If the thousands digit is an even number and the hundreds digit is 5 to 9, the selection starts at the No. 1 counting relay. If the thousands digit is an odd number and the hundreds digit is 0 to 4, the selection starts at No. 2 counting relay. If the thousands digit is an odd number and the hundreds digit is 5 to 9, the selection starts at No. 3 counting relay. The above has covered the four possible incoming group selections made for each 2000 consecutive numbers in the group of 10,000.

IG5

If the marker operates the IG5 relay, this indicates that the terminating equipment is serving two central offices using trunks in common and that the office called requires five additional pulses for incoming group selection. The operation of the IG5 relay transfers the make contacts of the No. 1' counting relay to the winding of the No. 6 counter.

FO-3

As previously described, the CR-5 relay is operated if the trunk group includes any trunks to non-repeating ground cutoff panel incoming selectors. If it is operated, the release of the FO-3 relay with the S-3 relay operated connects 25,500 ohms resistance across the FT and FR leads to discharge the trunk cable. This is done to avoid danger of a false pulse through the STP relay due to connection of the final circuit L relay to the fundamental. This bridge is opened when the FO-3 relay operates for final brush selection.

FINAL BRUSH SELECTION

Final brush selection is made with the S-3 and S-3' relays operated and starting when the FO-3 relay operates to close the fundamental circuit.

Final brush selection is controlled by the combination of H-0 to H-7 register relays operated.

FS-3

The FS-3 relay reverses the direction of current through the contacts of the STP relay to give longer life to these contacts.

FO-1 OR FO-2

On calls to panel offices, the FO-1 relay releases if the tens digit has been registered. On calls to crossbar, the FO-2 relay releases if the tens digit has been registered. Otherwise tens selection if delayed by a path which holds the FO-2 or FO-1 relay through contacts of the T-1, T-2, T-4 and TA-5 register relays released. This path is traced from either the winding of the FO-2 or FO-1 relay to the XB relay operated or released, respectively, make contacts FS-1, S-4 and FS-2, break contacts TA-5, T-1, T-2, T-4, IR-2 and STC to off-normal ground. When the tens digit is registered, it opens the holding circuit by the operation of one of the T-1, T-2, or T-4 relays.

FINAL TENS SELECTION

Final tens selection is controlled by the T-0 to T-7 register relays, the counting relay path being closed through by the S-4' relay operated.

TA-5

The counting relays are split for this selection as described for office group selection but controlled by the TA-5 relay if the tens digit dialed is 5 to 9. In this case the count starts at the relay pair numbered 5 less than the count desired, except for No. 5, the count for which starts at the No. 6 relays, using No. 0 lead. The counting relays when split, are connected to operate in the following order: 4, 3, 2, 1, 6, 5, 4, 3, 2, and 0. As previously described, the RC relay releases when the No. 5 relay operates and the No. 4, 3 and 2 pairs operated on the first cycle release when the No. 6 relay operates so that they may be used a second time. The bottom 4, 5 and 6 transfer contacts on the TA-5 are used to connect the operated contacts of the No. 1' relay and the SR-1 relay operated, either to No. 0 relay or No. 6 pair as required.

FO-1 OR FO-2

The FO-1 relay, if used, or the FO-2 relay, if the FO-1 is not used, releases only if the units digit and the start signal has been registered. Otherwise, units selection is delayed by a path which holds the FO-1 or FO-2 relay through contacts of the STC relay normal. The path for holding the FO-1 or FO-2 is traced from the winding of either relay to the XB operated or released, make contacts FS-1 and S-5, break contacts WU, make contacts FS-2, break contacts TCI, STC and LR-2, to off-normal ground.

FINAL UNITS SELECTION

Final units selection is controlled by the U-0 to U-7 register relays and takes place with the S-5 and S-5' relays operated.

The counting relays may be split for this selection as previously described except that the operated contacts of the No. 1' counter are connected to either the No. 0 or No. 6 counting relay by the combination of U-0 to U-7 register relays operated.

INCOMING ADVANCE

Incoming advance is a signal to the tandem sender that all selections were completed by the terminating office equipment. The signal is a single pulse of reverse battery from the distant office, this being battery on the FR lead and ground on the FT lead. Closure of this reverse battery advances the two-wire office selector from selection beyond position to talking position, if included in the routing of the call.

Incoming advance is made with the S-6 and S-6' relays operated, starting when the FO-3 relay operates to close the fundamental circuit after final units selection.

OF

The OF relay responds to this reverse battery pulse and operates because the polarity of the primary winding is now in the proper direction for its operation.

The path for operating the OF and STP relays is traced from battery on FR lead, break contacts FTT and AV, make or break contacts CR-1 and CR-2, make contacts FS-2, break contacts SS-3 and BO, winding STP, break contacts SS-3, make contacts FS-1, primary winding OF and in parallel with tertiary winding, break contacts FO-2, make contacts FO-3, break contacts AV, AV-2 and FTT, to ground on FT lead.

The OF relay locks through its secondary winding from ground on its own make contacts, break contacts WU and SS-5, secondary winding OF, break contacts AV-1 to battery on make contacts of DST relay.

IA

The IA relay operates from ground on make contacts OF, lead 22 to figure D, 35 lead to 32 lead, break contacts WU, lead 2 to 33 at figure D, back on lead 36, break contacts SS-5, lead 14 to 31 at figure D, make contacts S-6' and FS-1, to winding of IA relay.

With the STP relay operated and the closure of the IA relay contacts, the No. 0 counting relay operates and short-circuits the BO and FO relays in parallel.

STP

The incoming selector or terminating sender, after having connected the reversed battery, advances further and removes it causing the STP to release. This removes the short circuit from the BO and FO relays, which now operate.

Non-repeating ground cutoff panel incomings give so short a reversed battery pulse that the STP relay may not stay operated long enough after IA operates to operate the 0 relay, so the above described method of operating BO and FO at the end of the pulse may fail. To insure the operation of BO and FO, the IA relay closes a supplementary path through operated contacts of the CR-5 relay to operate 0, BO and FO simultaneously when the STP relay releases in case the 0 relay was not operated before.

The supplementary path would cause BO and FO to operate too soon in case the IA relay should close it before the STP relay operates. This is a possibility on long trunks which cause the STP relay to lag in operation behind the OF relay. It would cause the sender to proceed without insuring the advance of the incoming and checking that it does advance. To prevent this, the supplementary path is carried through the CR-5 relay operated as described above and is, therefore, ineffective on trunks not requiring it.

BO

When the incoming has cut off the reverse battery, it connects battery and ground again to the FT and FR leads, respectively, and awaits a trunk closure bridge before ringing the called station. The operation of the BO relay breaks the bridge across the fundamental in the sender to prevent premature trunk closure.

TRUNK CLOSURE

On a completed full selector call to panel or crossbar, the operation of the FO relay following reverse battery on incoming advance, operates the AV relay followed by the AV-1 relay. The tandem sender must now set the tandem trunk for trunk closure and supervision of the call.

AV-1

The AV-1 relay in operating connects ground to the D lead to the tandem trunk for operating the D and D-1 relays. When these relays have operated, a ground is connected back to the sender on the DC lead, operating the CK-1 relay. The CK-1 relay then operates the CK-2 relay, which locks.

CK-2

The CK-2 relay, in operating, disconnects ground from the CO lead. This causes the T relay to release in the tandem trunk circuit thereby setting it for trunk closure. The T relay released, also removes ground from the DC lead to the tandem sender, releasing the CK-1 relay.

The CK-2 relay opens the tip and ring connection between the trunk and the sender and receiver since the supervision of the call is now in the tandem trunk. It also gives protection to the tandem link crosspoints by opening the tip and ring before the link hold magnets release.

CK-4

The CK-4 relay is slow release for the purpose of allowing sufficient time for the tandem trunk A relay to operate for trunk closure and lock in the D relay before ground is disconnected from the D lead by the operation of the AV-4 relay.

SENDER RELEASE

The control of the call now having been transferred back to the tandem trunk satisfactorily and the AV-4 relay operated, the sender returns to normal through the release of the ON-1, ON-2 and ON-3 relays.

The ON-2 relay, in releasing, removes ground from the S lead, releasing the link hold magnets and upon the release of the ON-1 relay, ground is removed from the SB lead allowing the sender subgroup circuit SB relay to release, returning the sender to service for another call. The ON-3 relay releasing removes battery from the BAT-1, BAT-2 and BAT-3 leads to the receiving circuit, returning it to normal.

PANEL CALL INDICATOR EQUIPMENT

Panel call indicator equipment is provided in manual and tandem central offices for completing calls from mechanical offices.

Calls routed directly from an originating panel or crossbar office to a terminating manual office are called "direct PCI calls." There are some PCI calls which may route via a manual or mechanical tandem office, these being called "tandem PCI calls." On a direct PCI call, the numerical digits are sent to the terminating office, these digits consisting of a four or five-digit number of a four-digit number and the party letter W, R, J or M. On a tandem PCI call, the three-digit office code and the called line number are all sent to the tandem office. The tandem office may be manual or mechanical. If the tandem office is manual, the call is completed on a straightforward manual basis. If the tandem office is mechanical, the PCI pulses are transmitted to a tandem sender which may then complete the call on a mechanical basis to a crossbar or panel office; or again send PCI pulses to the local manual office; or complete on a call announcement basis to the local manual office.

Some manual offices have numbers over 10,000, but not beyond 10,499. Numbers over 10,000 do not have party letters.

The units digit on numbers over 10,000 or the party letter associated with a party-line number is registered on the stations register relays ST-0 to ST-7.

PANEL CALL INDICATOR CODE

PCI pulses used in transmitting a number consist of light negative, heavy negative and positive pulses. A light negative pulse is a closure of battery through high resistance (6500 ohms) on the ring of the trunk and ground on the tip. A heavy negative pulse is a closure of battery through low resistance (6500 ohms and 115 ohms in parallel) on the ring and ground on the tip. A positive pulse is a closure of battery through high resistance (6500 ohms) on the tip and ground on the ring. After transmission of the pulses for the number a final heavy positive pulse is sent, consisting of battery through low resistance (6500 ohms and 115 ohms in parallel) on the tip and ground on the ring, its purpose being to advance a distant office selector, if used, and to complete the display at the PCI position or advance a tandem sender.

These PCI pulses, when transmitted to the distant office, affect a group of three relays which are connected across the fundamental circuit. Two of these relays are polarized and the other is a marginal relay. One polarized relay operates on the light negative pulse and is known as the negative relay. The other polarized relay operates on the positive pulse and is known as the positive relay. The heavy negative pulse operates the marginal relay with the negative relay.

Each digit requires a cycle of four conditions. The first condition is the closure of a positive pulse or a blank period. The second condition is a light or heavy negative pulse. The third condition is a positive pulse or a blank period. The fourth condition is a light or heavy negative pulse. Negative pulses, either light or heavy, are always closed in the second and fourth pulse positions for a digit. These two negative pulses are sent for the purpose of advancing the call indicator or a tandem sender circuit so that the successive digits will be routed to the proper groups of register relays. Only light negative pulses perform this function; heavy negative pulses, in addition, cause register relays to operate. Positive pulses also cause the operation of register relays. The pulses are transmitted in a continuous stream.

PULSE CODE

	Tandem and Numerical		Pulse Closures			
Thousands	Hundreds, Tens & Units	Tens Thousands and Stations	1	2	3	4
0	0	0		Lt. Neg.		Lt. Neg.
2	1	1	Pos.	Lt. Neg.		Lt. Neg.
4	2	W (9)		Hv. Neg.		Lt. Neg.
6	3	R (7)	Pos.	Hv. Neg.		Lt. Neg.
8	4	J (5)		Lt. Neg.	Pos.	Lt. Neg.
1	5	M (6)		Lt. Neg.		Hv. Neg.
3	6		Pos.	Lt. Neg.		Hv. Neg.
5	7			Hv. Neg.		Hv. Neg.
7	8		Pos.	Hv. Neg.		Hv. Neg.
9	9			Lt. Neg.	Pos.	Hv. Neg.

Three different codes of pulse combinations are used. The first column is used for the thousands code only. The second column is used when transmitting the office code to a tandem office and for the hundreds, tens and units code. The third column is used for the stations code on 10,000 line numbers or party lines. The code for thousands is different from the code for hundreds, tens and units in order to transmit the number from the same register relay combinations for incoming and final selections, so that a tandem sender, in turn, controlling dial terminating equipment, does not have to perform the function of numerical translation.

Called numbers are spoken or dialed before the party letter; the party letter being registered on the stations digit register relays. However, in call indicator operation, the circuits are designed to send the party letter first when a party-line office is indicated. If the office called indicates 10,000 line numbers, then when numbers are registered from 100 to 104 on the thousands, hundreds and tens digits, the sender shifts the registration so that the thousands digit will be sent as stations (ten thousands), hundreds digit as thousands, tens digit as hundreds, units digit as tens and stations digit as units. When neither ten thousand line numbers or party lines are associated with the office called, two light negative pulses are sent first for a zero which causes a star to light in the stations digit of the call indicator.

On calls to an office having numbers over 10,000, some calls will have a registration of four numerical digits while others will have five. This sender does not need the so-called delay feature for a possible fifth numerical digit, as designed in other types of senders for such possibilities. It is not needed because of the start signal being sent at the completion of all calls to this M.F. sender. Therefore, when the start signal is received, the sender can be certain that all digits have been received.

PCI CALLS

The action of the sender circuit on PCI calls is as described for a full selector call up to trunk test, office selections being made or skipped as desired.

CLASS OF CALL

The marker, when selected, operates the class relays CI, XB, OD and TCI in combination for the particular PCI call.

CI, XB, TCI	PCI Direct
CI, TCI	PCI Tandem - 7 or 8 Digits
CI, OD, TCI	PCI Tandem - 3 Digits

The CI and TCI relays operate for all PCI calls. The CI relay, in operating, short-circuits the PG condenser and energizes the primary winding of the PG relay in the release direction holding the PG relay on its back contact. The TCI, in operating, removes the 14,500-ohm resistance from the fundamental circuit as described later.

The SD-1 relay is operated by the marker on all PCI calls except on calls to manual offices having numbers over 9,999.

PCI DIRECT - FOUR-DIGIT NUMBERS ONLY

For these calls the XB and SD-1 relays are operated. When the DRL and ST relays are both operated, a path is closed to operate the C and C' relays. The C relay then closes a path to operate the STB and STB' relays, the STB' relay operating the STC relay.

For this call, the sender starts pulsing from the stations digit register relays but since none have been operated, two light negative pulses are sent followed by the thousands, hundreds, tens and units digits.

PCI DIRECT - FOUR OR FIVE DIGIT NUMBERS

For these calls the XB relay is operated but the SD-1 relay is not operated. When the DRL and ST relays are both operated, a path is closed to operate the C and C' relays. The C relay operated causes either the STB and STB' relays or the STA and STA' relays to operate.

The STB and STB' relays are going to operate if only a four-digit number is received, this path being closed through all stations digit register relays released, break contacts SS-5, make contacts UL, C, DRL and ST to ground. If a four-digit number and party line is received, a path is closed to operate the STB and STB' relays through the thousands digit or hundreds and thousands digit register relays, break contacts SD-1 and SS-5, make contacts UL, C, DRL and ST to ground.

The STA and STA' relays are going to operate through the make contacts of the C relay if a five-digit number is received, having a thousands, hundreds and tens digit No. 100 to No. 104. This path is through the break contacts TA-5, thousands digit 1, hundreds digit 0, break contacts SD-1, make contacts ST-0, ST-1, ST-4 and ST-2, make contacts SS-5, make contacts UL, C, DRL and ST to ground.

PCI TANDEM - SEVEN OR EIGHT DIGITS

This type of call has the XB relay down and the SD-1 relay may be up or down. When the DRL and ST relays are both operated, it is possible to operate either the STB and STB' or the STA and STA' relays.

The STB and STB' relays are going to operate if no stations digit is received, or if there is a stations digit with a thousands digit No. 0 or No. 2 to 9, or should there be a stations digit with thousands, hundreds and tens No. 105 to No. 109.

The STA and STA' relays are going to operate when there is a stations digit with a thousands, hundreds and tens No. 100 to No. 104.

PCI TANDEM - THREE-DIGIT CODE

This type of call has the XB relay down and the OD and SD-1 relays operated. When the CRL and ST relays have operated, the STB and STB' relays operate through make contacts OD, break contacts XB, make contacts DRL and ST to ground.

DELAY TRUNK TEST

FO-1

On a PCI call, the FO-1 relay is used to delay trunk test until all numerical digit registration is completed. This is accomplished by the operation of the class relay TCI. With TCI relay operated, the control is connected directly to the STC relay.

When the S-6 relay operates and should digit registration not be completed, a circuit is closed to operate the FO-1 relay. This path is traced from battery on the winding FO-1, break contacts FS-1, make contacts S-6, break contacts SS and LR-2, make contacts TCI, break contacts STC and LR-2 to off-normal ground. The FO-1 relay operates the FO-2 relay which releases the FO-3 and RC relays. The FO-3 relay, in releasing, opens the fundamental circuit preventing trunk test until the STC relay operates to release the FO-1 relay.

TRUNK TEST

TG

The fundamental circuit is closed for trunk test when the S-6' and FO-3 relays are operated. The battery and ground to operate the TG relay are furnished at the tip and ring, respectively, of the call indicator trunk circuit, and are connected through the tandem trunk, the office link and trunk link frames and the tandem sender link to the sender.

The operation of the class relay TCI removes the 14,500-ohm resistance from the fundamental circuit for PCI calls, consequently the TG relay operates either on 48 or 24-volt battery. The required compensating resistance used is controlled by the CR-1 and CR-2 selection register relays.

The operating path for the TG relay is traced from FT lead, break contacts FTT, AV-2 and AV, make contacts FO-3, break contacts FO-2, the operating winding of OF not shunted by its non-inductive winding, break contacts FS-1, winding TG, break contacts CR-5, OP-2, CI-2 and SS, make contacts TCI and S-6', compensating resistance as determined by transfer contacts of CR-1 and CR-2, break contacts AV and FTT, to FR lead. The OF relay does not operate in this circuit because of its polarity unless the trunk is found reversed.

CI-1 & CI-2

The CI-2 relay, in operating, short-circuits the operating winding of the OF relay to prevent it from responding to a momentary false overflow indication, which may occur due to the trunk being disconnected from a previous connection after being seized on this call.

The CI-1 and CI-2 relays are slow operate to allow time for the OF relay to operate before its short circuit is connected on an actual distant office overflow, telltale or a trunk wired reverse.

When the CI-2 relay is operated and the sender is waiting for assignment of the PCI trunk, the fundamental is traced from FT lead, break contacts

FTT, AV-2 and AV, make contacts FO-3, break contacts FO-2, make contacts S-6 and CI-2, break contacts FS-1, winding TG, break contacts CR-5 and OP-2, make contacts TG-2 and CI-1, compensating resistance through CR-1 and CR-2, break contacts AV and FTT, to FR lead.

TRUNK ASSIGNED

TG

When the TG relay is bridged across the fundamental circuit, a relay in the PCI trunk circuit operates to signal a manual operator or automatic equipment (automatic display call indicator). If an operator is involved, she depresses the assignment key associate with the trunk, which opens the tip and ring of the trunk or if A.D.C.I. equipment is involved, the tip and ring is opened when an idle operator is selected. This causes the TG relay to release.

The condenser and resistance bridge across the winding of the TG relay absorbs its discharge to prevent transmission of a false pulse.

TG-1

The TG-1 relay is slow release to prevent a false assignment in case TG is momentarily released, which may happen if the trunk is still connected to a subscriber's line from the previous connection and he should hang up the receiver while the sender is awaiting assignment. The TG-1 relay can not release until the CI-2 and PG-2 relays have both operated to be sure that the pulsing circuit is ready to send pulses.

TG-2

The release of the TG-2 relay connects ground to FT and FR leads to clear the fundamental circuit of any capacity condition that may be existing at this time. The fundamental circuit at this time is from ground on the GR relay, break contacts GR, PT, FP and TG-2, make contacts CI-1, break contacts AV, AV-2 and FTT to FT lead, back on FR lead, break contacts FTT, AV, CR-1, CR-2, CI-1, TG-2 and FP to ground on make contacts of PG-1 relay.

GENERATION OF PCI PULSES

PG

The PG relay provides the uniform time intervals for generating the PCI pulses to the distant office. The time performance is measured during its operated period for one pulse, then during its released period for the next pulse, etc. The PG relay is a non-biased condenser-timed polarized relay. It can not be said to operate and release but it closes its front contact when energized in one direction by its primary winding, closes its back contact when energized in the other direction by its primary winding, and remains on either contact or between the contacts when not energized. When current is first closed through the primary winding in either direction, its force is more than neutralized by an opposing current in its secondary winding, the source of which is the charge or discharge of the PG timing condenser. When the condenser has been charged or discharged, current ceases to flow in the secondary and the primary causes the armature to move over from one contact to the other. The actual time of operation varies somewhat with variations in voltage, resistance and relay adjustment. It averages about .069 second per single operation in one direction. Jack PG affords a means to patch the windings of relay PG separately to a relay test set.

Operation of the CI relay, as stated above, causes the PG relay to close its back contact after a time interval. This is accomplished by the closure of opposing parallel paths from ground at the CI relay operated, through normal contacts of the SP relay, through both windings of the PG relay in parallel, the primary winding being connected to battery through part of the M resistance and the secondary winding being connected to the PG condenser which has a negative charge. The path through the primary winding is in the release direction of the relay, and the path through the secondary winding is in the operate direction.

At first, the effect of the secondary winding is stronger, but as the condenser discharges, the current in the secondary is decreased until the effect of the primary becomes stronger, causing the relay to close its back contact.

SP

When the SP relay operates to start the transmission of pulses, it disconnects the ground at the CI relay which was short-circuiting the PG condenser and holding the primary winding energized in the released direction, and connects in its place the front contact of the PG relay. Removal of the CI relay ground permits battery through the L resistance to flow through the primary winding of the PG relay, in the operate direction, through a winding of the M resistance to ground at the CI-1 relay, and sets up an opposing current from the same battery through the secondary winding charging the condenser. At first, the effect of the secondary winding is stronger and the back contact is held closed, but as the condenser charges, the current in the secondary is decreased until the effect of the primary becomes stronger, causing the relay to break its back contact and close its front contact.

The CI-1 and SP relays having been operated, ground is now connected to the armature of the PG relay, and its front contact is connected to the L resistance. Closure of the front contact consequently, grounds out the 300-ohm battery and so starts opposing currents in the two windings as before, the current in the primary winding being in the release direction, its effect, however, being delayed until the condenser is sufficiently discharged.

The PG relay continues to operate and release in this manner during the transmission of pulses, and with the aid of the PG-1, PG-2 and PG-3 relays closes the paths required for the four pulse positions for each digit, as described later. Pulses are transmitted while the opposing currents are flowing in the windings of the PG relay, each pulse being connected to the fundamental leads for approximately .069 second, which is the length of time required to charge or discharge the PG condenser to the point at which the primary winding of the PG relay is effective. It can be seen that the PG relay is held on its back contact while the PG condenser is charging and on the front contact while the PG condenser is discharging.

PG-1, PG-2 & PG-3

The PG-1 relay is first operated when the CI-1 relay operates during trunk test. The PG-1 relay then operates the PG-2 relay and short-circuits the PG-3 relay. The PG-2 relay locks. Thus, the PG-1 and PG-2 relays are operated before pulsing starts.

When the PG relay starts its continuous timing, each time it operates, the PG-1 relay is released, and each time the PG relay releases, the PG-1 relay is operated. Therefore, the PG-1 relay is up in the first and third quadrants and down in the second and fourth quadrants.

As the PG-1 relay operates and releases, it affects the operation and release of the PG-2 and PG-3 relays. On the first release of the PG-1 relay, the short circuit is removed from the PG-3 relay which operates. On the second operation of the PG-1 relay, the PG-2 relay is short-circuited and releases, the PG-3 relay being held operated. On the second release of the PG-1 relay, the PG-3 releases. On the third operation of the PG-1 relay, the PG-2 relay operates and locks, the PG-3 relay is short-circuited. This is the start of another cycle as just described. These cycles continue until the heavy positive pulse is sent. It can be stated from the above, that the PG-2 relay is operated in the first quadrant and released in the third quadrant for each digit. That the PG-3 relay is operated in the second quadrant and released in the fourth quadrant for each digit.

Digit Pulsing		PG-1	PG-2	PG-3
PG Down	1st Quad	Up	Up	Down
PG Up	2nd Quad	Down	Up	Up
PG Down	3rd Quad	Up	Down	Up
PG Up	4th Quad	Down	Down	Down

The function of the PG-2 and PG-3 relays is to provide the closures for positive or negative pulses, as they are required, by closing and opening the operating paths for the PT and PR relays, as explained in the following paragraphs.

PT & PR

The FT and FR leads for the fundamental circuit terminate at the FP relay and from this point the PCI pulse conditions must be connected. It will be noted that with the PG-1 and GR relays normal, ground is connected to the FT lead and 6,500-ohm battery is connected to the FR lead, this being the closure for light negative pulses. A light negative pulse must always go out in the second and fourth quadrant, regardless of whether a heavy negative pulse is to be superimposed onto these light negative pulses. This is made possible by the PG-1 relay being down in the second and fourth quadrant.

If a heavy negative pulse is required in either the second or fourth quadrant, then a path will be closed to operate the PR relay (as explained later) in the first or third quadrant, respectively, of the same quad. The PR relay, in operating, connects 115-ohm battery in parallel with the 6,500-ohm battery to the FR lead. While the PR relay is operated before its actual use, it can not become effective in the first or second quadrant since at that time, the PG-1 relay is operated and has ground connected to the FR lead for a positive pulse, at the same time shunting these batteries.

A positive pulse requires the operation of the PT relay. The PT relay connects 6,500-ohm battery to the FT lead and ground is connected to the FR lead by the operated contacts of the PG-1 relay.

When a positive pulse is required in the first or third quadrant, a path will be closed to operate the PT relay (as explained later) in the fourth quadrant of the previous digit or in the second quadrant of the present digit, respectively. While the PT relay is also operated in advance of its use, it can not become effective until the first or third quadrant because in the fourth or second quadrant, as described above, the PG-1 relay is released connecting ground to the FT lead for a negative pulse and at the same time shunting the 6,500-ohm battery for the positive pulse.

12 & 34

The 12 and 34 relays, by their designation, gives reference to the first and second quadrant and the third and fourth quadrants, respectively.

When a digit requires a positive pulse followed by a heavy negative pulse in the first and second quadrant, the 12 relay will be operated as explained later. The 12 relay, when required, operates in the third quadrant of the previous digit. Its function is to operate the PT relay through the PG-3 relay released and the PR relay through the PG-2 relay operated. The PT or PR relay under control of the 12 relay are still dependent upon the condition of the PG-1 relay, as already described.

When a digit requires a positive pulse followed by a heavy negative pulse in the third and fourth quadrant, the 34 relay will be operated, as explained later. The 34 relay operates in the first quadrant of the digit for which it is required. Its function is to operate the PT relay through the PG-3 relay operated and the PR relay through the PG-2 relay released.

The 12 and 34 relays are furnished in order to reduce the number of contacts required on the digit register relays.

GR

The GR relay is a slightly slow operate relay in order that its break contacts be closed momentarily with the make contacts of the PG-1 relay as it operates. The purpose of this arrangement is to provide a means for grounding the FT and FR leads, momentarily before a blank pulse takes place, to discharge any existing trunk capacity which would tend to give false operations. This short circuiting path is from ground on break contacts of GR, through break contacts of PT and FP, to FT lead, back on FR lead, make contacts PG-1 to ground. If a positive pulse is to be transmitted instead of a blank pulse, the PT relay being operated, prevents this fundamental discharge circuit from taking place.

CONNECTING PCI PULSING CIRCUIT TO DIGIT REGISTER RELAYS

When the SP relay operates, the PCI pulses are transmitted in a continuous stream, the stations being first followed by the thousands, hundreds, tens, and units, if the call is a PCI direct. If the call is a PCI tandem, then the office code is sent first, followed by the stations, thousands, hundreds, tens and units. The above, as stated, is the order in which the pulses are recorded at the distant office and does not necessarily mean the order in which the stations, thousands, hundreds, tens and units digit register relays will be used in the sender. This depends upon the way in which the STA and STA', STB and STB' or C and C' relays are operated for the call. These relays together with the A, A', B, B', TH, TH', H, H', T, T', U and U' function to connect the pulse generating circuit to the digit register relays as required.

The A, A', B, B', C, C', STA, STA', etc., when required for the call, operate in a like manner as previously described for counting relays. The top No. 4 and No. 5 contacts of the PG-2 relay provides the pulses for their operation. The PG-2 relay upon each release, operates the relay of the pair (A, B, C, STA, etc.) and upon each operate of the PG-2 relay it allows the prime relay of the pair to operate (A', B', C', STA', etc.). This means that each time the PG2 relay has operated and released, one transfer relay is operated.

Each time a transfer relay operates, ground on the bottom No. 4 and No. 5 contacts of the CI-1 relay is being transferred to the next group of digit register relays. This ground serves two paths, one through the contacts of the relay of the pair and the other through the contacts of its prime relay. It will be noted that each time one of these transfer relays operate, this ground is transferred to the next group of digit register relays.

On a PCI direct, four digits only, the C and C' relays are operated, therefore, the control ground is connected to the STA and STA' leads and will end at the U and U' leads because the STB and STB' relays are operated.

On a PCI direct, four or five digits, the C and C' relays are operated, therefore, the A and B groups of transfer relays are eliminated. If it is a five-digit call, starting with 100 to 104, the STA and STA' relays are operated and the control ground is connected to the TH and TH' leads. After the U and U' relays operate, the control ground is connected to the STB and STB' leads to the stations digit register relays for units pulses because the STB and STB' relays are not operated. If the call is a four-digit number, the control ground is connected to the STA and STA' leads, the STA and STA' relays not being operated, but the STB and STB' relays are operated, ending the pulse at the U and U' relays.

On tandem calls, the C and C' relays are not operated at the start of the call, therefore, the control ground is connected to the A and A' relays to start with the office code. After the pulsing has progressed to the operation of the C and C' relays, then it depends upon whether the STA and STA' relays are operated or released. This would be controlled as described in the previous paragraph.

Each pair of transfer relays lock up either to the pair operating it or to off-normal ground.

CONNECTING POSITIVE AND HEAVY NEGATIVE PULSES

It was previously stated that the pulsing circuit must connect two light negative pulses for each digit, regardless of the number called, in order to provide for the advancement of the PCI circuit at the distant office, from digit to digit. Only by the operation of the PT or PR relay can a positive pulse be connected or a heavy negative pulse superimposed onto a light negative, respectively. As for example, if the number called was 0000, all light negative pulses would be connected because no paths would be closed to operate the PT or PR relay at the digit register relays.

When tracing the paths for the operation of the PT or PR relay, or for the operation of the 12 or 34 relay, it must be assumed that the numbered rectangles appearing in figure "A" are connected to like numbered rectangles associated with the digit register relays.

If a PCI call is going to require a positive pulse or a positive and heavy negative pulse in the first quadrant to be sent, the PT, PR, 12 or 34 relay, or some combination of these relays, will be operated as soon as the CI-1 relay operates. If a nine is registered for the A digit on a tandem call, then the 34 relay has a path to operate, but the PT and PR relays will not operate through its contacts until the PG-3 relay operates and the PG-2 relay releases, respectively. If a three is registered for the A digit, the 12 relay operates, immediately operating the PT relay and when the PG-2 relay has operated for the first time, the PR relay comes up. If a "one" is registered on the thousands digit for a PCI direct with a five-digit number starting with 100 to 104, the PT relay is operated immediately from the thousands digit register relays for the positive pulse. On a PCI direct call with a party W or R, the PR or 12 relay, respectively, is operated immediately through the stations digit register relays.

Each time the PG-3 relay operates, it will open the path and release the PT relay if it was used for the first quadrant or it will operate the PT relay if it is required for the third quadrant. Each time the PG-3 relay releases, it will open the path and release the PT relay if it was used for the third quadrant or it will operate the PT relay if it is required for the first quadrant for the next succeeding digit.

Each time the PG-2 relay releases, it will open the path and release the PR relay if it was used for the second quadrant or it will operate the PR relay if it is required for the fourth quadrant. Each time the PG-2 relay operates, it will open the path and release the PR relay if it was used for the fourth quadrant or it will operate the PR relay if it is required for the second quadrant.

When the A, B, C, STA, TH, etc., relays operate as already described, it will open the path and release the 12 relay if it was used for the first and second quadrants of the present digit or it will operate the 12 relay if it is required for the first and second quadrants of the next succeeding digit.

When the A', B', C', STA', TH', etc., relay operates as already described, it will open the path and release the 34 relay if it was used for the third and fourth quadrants in the previous digit or it will operate the 34 relay if it is required in the third and fourth quadrants of the present digit.

FINAL HEAVY POSITIVE PULSE

After the pulses for the number have been sent, the fundamental leads are grounded as for an open pulse. A final heavy positive pulse is then transmitted to complete the display at the called office (or advance a tandem sender on a tandem call) and to advance a distant office selector, if included in the routing, from selection beyond position to talking position. This pulse consists of closure of low resistance battery to the FT lead and ground to the FR lead in the sender. It is of the same polarity as the reversed battery pulse received from panel or crossbar terminating equipment during incoming advance on a full selector call, and acts to advance a distant office selector in the same manner.

FP

When the PG relay releases for the fourth quadrant in the units digit, the PG-1 relay operates, in turn, operating the PG-2 relay. The short circuit is then removed from either the U' or STB' relay allowing one of these relays to operate as the last transfer relay. When this takes place, the FP relay is operated. The fundamental circuit is discharged on the operation of the PG-1 relay and before the GR relay has operated.

The operation of the FP relay connects 115-ohm battery in parallel with 6500-ohm battery to the FT lead, but this battery can not be effective at this time because it is being shunted by ground from the operated contacts of the PG-1 relay.

When the GR relay has operated and removed ground from the FR lead, a blank pulse is sent, while condenser timing is taking place for the next operation of the PG relay.

On the next operation of the PG relay, the PG-1 relay releases and removes the ground from the FT lead, and when the GR relay releases, the heavy positive pulse is connected to the fundamental circuit.

On the next release of the PG relay instead of operating the PG-1 relay, it releases the PG-2 relay, this being accomplished by short-circuiting the battery supply for the PG-2 with the FP relay operated.

AV & AV-1

When the PG-2 relay releases during the connection of the heavy positive pulse, it closes a path to operate the AV relay. This circuit is traced from battery winding AV relay, make contacts STB', U', T', H', TH', STA', C' and SP, break contacts PG-2 and FO-3 to ground.

The operation of the AV relay opens the fundamental circuit, disconnecting the heavy positive pulse. The AV relay operates the AV-1 relay for disconnection of the sender.

The operation of the AV-1 relay releases, in turn, the CI-1, CI-2 and STB and STB' relays. The CI-1 relay in addition releases the SP, PG-3 and FP relays. When the STC relay releases, the TH, TH', H, H' and the A, A', STA, STA' relays release this depending upon the type of call. The A relay will release the B and B', in turn, releasing the C and C'. The H relay releases the T and T', which releases the U and U'.

THREE-DIGIT TANDEM PCI

It is possible for this tandem sender to complete calls to a tandem PCI office, which only requires an office code. In this case, the marker, when it returns its information to the sender, will operate the CI, OD and TCI class relays. The OD relay causes the operation of the STB and STB' relays when the DRL relay operates. The STB' relay causes the STC relay to operate. The call then proceeds as a regular tandem PCI call. The code is pulsed but due to the fact that no numerical digit register relays have been operated, all zeros are sent for the numerical number. The sender then disconnects as for a regular PCI call.

STRAIGHTFORWARD CALLS

It is possible for "A" switchboard operators to complete calls requiring the dialing of only three digits. There is no difference in the trunk used in this case. When the operator has keyed the third digit of the office code, the tandem marker is called in as in a regular call. The marker recognizes the fact that the code is for a three digit call. From this point there are two classes of calls that may be completed on a straightforward basis. One class, which is the "straightforward direct" class, and is completed without office selections. The other class is the "straightforward through revertive pulse tandem," which is completed through a second crossbar tandem sender and requires office selection.

Both cases are outlined in the following.

STRAIGHTFORWARD DIRECT

The "A" switchboard operator will key three digits for the office code when she receives the start signal. After the code has been sent, the operator waits for an order tone from the distant office. On receiving this tone she will pass the number orally.

The tandem marker in this case will take the office code and return to the sender an OD, TCI and SO indication. The OD relay permits the call to be completed after 3 digits have been registered.

In order to avoid having the order tone returned before the sender has completed its functions, a trunk test is not made on the straightforward trunk. This test, however, is simulated in the sender in order to cause its advance.

FTT

Following the operation of the DRL relay, a circuit is closed to operate the FTT relay, from battery winding, break contacts TW, make contacts TCI, break contacts CI, make contacts DRL, to off-normal ground. The FTT relay, in operating, disconnects the TG and OF relays from the FT and FR leads and connects them to battery and ground respectively, to simulate trunk test within the sender. This circuit is as follows: battery through W resistance, at FTT relay, make contacts FTT, break contacts AV-2 and AV, make contacts FO-3, break contacts FO-2, winding OF not shunted, break contacts FS-1, winding TG, break contacts CR-5, OP-2, CI-2 and SS, make contacts TCI and S-6', break contacts CR-1, CR-2 and AV to ground on make contacts FTT.

When this circuit is closed following marker release, TG operates followed by TG-1 and TG-2. The TG-2 operates the AV and AV-1, followed by sender release in the usual manner. The usual check for open trunk, as explained later, is cancelled by a back contact of the FTT relay.

STRAIGHTFORWARD THROUGH SECOND TANDEM

The tandem marker for this call will return to the sender an OD, TCI and TW indication, with an office brush and office group selection register relay setting.

OP-1

Following the operation of the DRL relay, the OP-1 relay operates, due to the operation of the TW and TCI relays.

OFFICE SELECTIONS

Following the release of the DC relay, office test will be made in the usual manner as described for a full selector call, followed by office brush and office group selections. The office brush and office group selections provide a code to the second tandem office revertive sender for selection of a trunk to the terminating office.

TRUNK TEST

After office selections are completed, the second tandem revertive sender closes the fundamental circuit to this sender for trunk test for operating the TG relay. The operating path for the TG relay is from FT lead, break contacts FTT, AV-2 and AV, make contacts FO-3, break contacts FO-2, operating winding OF not shunted, break contacts FS-1, winding TG, break contacts CR-5, OP-2, CI-2 and SS, make contacts TCI and S-6', break contacts CR-2, CR-1, AV and FTT, to FR lead.

OP & OP-2

The TG relay operation is followed by the TG-1 and TG-2. With the TCI operated, the TG-2 operates the OP relay, which locks. The OP operated, releases slow release OP-1. When the OP-1 has released, it closes a path to operate the OP-2 relay, which locks. The OP-2, in operating, opens the fundamental circuit, releasing the TG, TG-1 and TG-2 relays. At the same time this allows the distant tandem revertive sender to advance to awaiting trunk closure.

OP

The TG-2 relay, in releasing after trunk test, releases the OP relay. With the OP released, the locking ground for the OP-2 relay is extended through the break contacts of OP, make contacts OP-2 to operate the AV relay. The AV relay then operates the AV-1 for release of the sender. The release of the M.F. sender sets the tandem trunk which gives trunk closure to the distant tandem revertive sender. The distant tandem revertive sender then releases, and the distant tandem trunk to the terminating office is closed through to the originating office. The "A" switchboard operator then upon receiving order tone from the terminating office passes the number orally.

REORDER

At the completion of the required digit frequencies for any call, a start signal follows consisting of frequencies 7 and 10 (1500 and 1700 cycles). The normal purpose of the ST signal, when registered, is to indicate that all digits have been completely transmitted to the sender.

Should the ST signal be received prematurely due to an operator's error or a trouble condition, a reorder signal is returned to the originating office. The reorder signal is to give alternate reversals of the battery and ground connected to the tip and ring to the originating office.

OE

The ST signal received prematurely operates the OE relay, which locks.

The ST signal causes the 7 and 10 channel relays to operate and to ground the 7 and 10 leads to the sender. The 7 lead will operate the No. 7 digit register relay, depending upon the progress of the call. However, the 10 lead will operate the OE relay, through the break contacts of B-0, B-1, B-2 and BB-5 relays, if the ST signal is received following the KP signal or following insufficient digits for an office code. The OE relay is operated through the break contacts of the CL and 11A' relays should these relays be down with a B digit registered. The OE relay operates from ground on 10 lead, if the UL relay is normal with the H-7 relay operated or the H-7 normal and the HL operated, if the ST signal is received in place of the hundreds, tens or units digit.

The OE relay is operated if after the regular KP signal, a second KP signal is sent in error.

If the start signal is received following any code, without registration of a complete number, and the marker does not recognize this code as an operator's code, the OE relay is operated. The marker in this case does not operate the OD relay. When the ST and DRL relays are both operated, a path is closed from winding of OE relay, break contacts UL, OD and XB, or through make contacts of C (if XB is operated) make contacts DRL and ST, off-normal ground to operate the OE relay.

PU-1 & PU-2

When the OE relay operates, it opens the J and L leads to the receiving circuit, releasing the 7 and 10 channel relays, and connects a holding circuit to the RV-1 relay. The opening of the J and L leads to the receiver is to prevent the reception of any further digits. The OE relay operated, connects resistance battery to the FL interrupter to start a cycle of timing for reorder flashing. When the FL interrupter closes its B contact, the PU-1 relay operates and locks to the battery from the contacts of OE relay. When the FL interrupter closes its F contact, the PU-2 relay operates and locks.

RV-2

On each subsequent closure of the FL interrupter B contact, a circuit is closed to operate the RV-2 relay. On each subsequent open of the B contact, the RV-2 relay releases. During the operated periods of the RV-2 relay, the RV-1 relay is released and during the released periods of the RV-2, the RV-1 is operated. The alternate release and operate of the RV-1 relay, alternately reverses the battery and ground on the L relay to the originating office as a reorder signal. This reorder flash causes the supervisory lamp to flash in the cord circuit at the originating switchboard as a signal to the operator to reassign this call. The time interval for these flashes is approximately

.250 of a second; the B contact closure being .295 and an open interval of .205. This signal continues for a timed interval as explained later, or until the originating end disconnects.

The L relay will be flashed by the RV-1 relay. Since the SR relay is slow releasing, it remains operated.

MORE THAN TWO FREQUENCIES FOR ONE DIGIT

As already stated in a regular call, the receiving circuit CK1, CK-2 and CK-3 relays are for the purpose of signal counting to recognize that a correct digit signal consisting of two frequencies and only two have been received. When more than two frequencies appear for anyone of the digits, the balance in the windings of the CK-3 relay are changed. This is because three grounds are removed from the back contacts of three channel relays changing the potentiometer effect of the OC and OB to 7C and 7B resistances, thus causing the operation of the CK-3 relay in addition to the CK-1 and CK-2 relays. The CK-3 relay, in operating, grounds the RO lead, operating the OE relay. The OE relay operated, performs the same functions as previously described.

ONLY ONE DIGIT REGISTER RELAY OPERATED FOR ONE DIGIT

It was previously stated that the TO relay is marginal and only operates when two register relays are operated for a digit. That the operating current for its primary winding depends upon the parallel of the secondary windings of two register relays.

If only one digit register relay is operated for a digit, the sender TO relay will fail to operate. Likewise, the CK-1 and CK-2 relays in the receiving circuit will fail to operate because only one channel relay was operated. Therefore, the AA and AB, BA and BB, CA and CB relays, etc., whichever are involved will remain operated. When the frequencies for this digit are off, the tertiary winding for the one channel relay releases the relay, which in turn, releases the one register relay in the sender. Since there has been no transfer made in the sender to the next digit register relays, the next succeeding frequencies for the remaining digits will be registered falsely. This will allow for the ST signal to be recorded in the last numerical digit, thereby causing a reorder signal, as already described.

If due to a trouble, only one digit register relay was operated, but the required two frequencies were received satisfactorily, the TO relay will fail to operate and break the screen grid lock. In this case, when the succeeding frequencies are received, the first digit having a frequencies other than the two recorded, causes the CK-3 relay to operate and ground the RO lead for reorder.

REORDER ROUTING AND VACANT CODES

When the marker finds all regular trunks busy, it selects an overflow trunk and operates class relays OD and TCI in the sender for this condition. With these class relays operated, trunk test is simulated and the call is completed as described previously under "straightforward direct call." When the tandem trunk makes trunk closure, the overflow trunk returns alternate reverse battery as a reorder signal to the originating office.

Vacant codes are treated exactly the same as overflow routing.

MARKER TRIALS

FIRST TRIAL WITH MARKER

The DST relay operates when the CL or ST relay operates. The DST relay operated, connects battery to leads ST and CBS to the marker connector, with the effect that the latter connects the sender to an idle marker as soon as the connector and a marker are available. In connecting through to the marker, ground is sent over the TR-1 lead from the break contacts of the TR-3 relay as an indication of first trial.

TROUBLE RELEASE IN FIRST TRIAL

TRL, TR-1 & TR-2

If the first marker encounters trouble in receiving information from the sender, in decoding, or in transmitting information to the sender, it sends a trouble release to the sender by way of the connector, by grounding the TRL lead. This operates the TRL relay, followed by the operation of the TR-1 relay. The TR-1, in closing its contacts, short-circuits the TR-2 relay. The TR-1 relay releases the DST relay which breaks the ST lead, thereby releasing the connector and breaking all direct connections between the sender and the marker.

Release of the connector opens the TRL lead, releasing the TRL relay which removes the short-circuit from the TR-2 relay, allowing it to operate in series with the TR-1. The TR-2, in operating, disconnects ground from the TR-1 lead and connects ground to the TR-2 lead as an indication of second trial, when connection is made to the second marker. The TR-2, also operates the TG-6 relay, which releases the TG-3 relay, thus cancelling the feature for test of open trunk as described later. The DST relay now reoperates from the TR-2 with the result that a second connection is made through the marker connector to a marker. This may be the same marker as before, but usually will be a different one since the first marker holds itself busy momentarily after sending a trouble release. The second marker will try to establish the connection the same as the first did except that the order of testing trunks is reversed.

If the first marker encounters trouble on an all paths busy condition, when trying to establish connection to a chosen idle trunk or an overflow trunk, after its direct connection to the sender has been broken by the release of the connector, it sends a trouble release through the trunk link frame. The marker grounds its TRL lead, which is connected by the trunk F relay to the sender link D lead to the sender, operating the TRL relay. The sender functions the same to operate the TR-1 and TR-2 relays as explained for the trouble release through the connector, except that when the DST relay releases, it releases the DRL, FO-3, RC and S-3 or S-6 relays. The release of the DRL, in turn, releases all operated selection register relays.

RO

If the first marker encounters an all trunks busy condition, including overflow trunks, it grounds the RO lead through the connector, operating the RO relay, which then locks. The RO relay operates the DRL relay, which holds the relays operated by the marker and opens the ST lead releasing the marker connector and marker.

The RO relay connects resistance battery to the FL interrupter, operating the PU-1 and PU-2 relays to send reorder flashes to the originating office, as already explained under "Reorder."

TROUBLE RELEASE IN SECOND TRIAL

TR-3 & TR-4

Should a marker selected for a second trial encounter a trouble condition, or all trunks busy including overflow, or all channels busy, the TRL or D lead is grounded through the connector or sender link, respectively. This ground operates the TRL relay which then operates the TR-3 relay because the TR-1 and TR-2 are already locked up. Closure of the TR-3 contacts short-circuits the TR-4 and when ground is removed from the TRL or D lead, The TR-4 relay operates. The TR-3 relay releases the DST relay, releasing the connector. The TR-3 relay removes ground from the TR-2 lead and connects ground to the OF lead of the connector to indicate a third trial when it selects the next marker.

When the TR-4 relay operates the DST relay and a marker is reselected, ground on the OF lead notifies the marker to establish connection to an overflow trunk. The marker will send the selection information to the sender, operate the DC relay, operate the DRL relay, connect the tandem trunk and release the DC relay, just as described for connecting to a regular trunk. Trunk test is simulated on a third trial call which has selected an idle overflow trunk.

TROUBLE RELEASE IN THIRD TRIAL

If a marker selected for third trial should encounter trouble, or if an idle overflow trunk is selected but all channels are busy or should all overflow trunks be busy, the marker grounds the TRL lead for the first two conditions or the RO and TRL leads for the third condition, respectively. The TRL ground operates the TRL relay, and because the TR-1, TR-2, TR-3, TR-4 are all operated, the RO relay operates or the RO lead ground operates the RO relay directly. The RO relay, in operating, causes the FL interrupter to function as previously described.

SUMMARY OF TROUBLE RELEASE CONDITIONS

	Lead Grounded		
Conditions	1st Trial	2nd Trial	3rd Trial
Trouble Condition in Decoding Stage	TRL	TRL	TRL
Trouble Condition after Decoding Stage	D	D	D
All Trunks Busy including Overflow	RO	TRL	RO & TRL
All Channels Busy	D	D	

TRUNK GUARD FAILURE

The TM4 interrupter, the TG-3, TG-4, TG-5 and TG-6 relays are furnished for the purpose of checking for an open trunk and then when indicated to select another marker and notify it that the previous marker had selected an open trunk. This procedure can only take place if the sender has made only one trial.

Upon the start of each call when the ON-1 relay operates, a path is closed to operate the TG-3 relay through the back contacts of the TG-6 relay.

TG-4 & TG-5

When the S-3' or S-6' relay operates for office test (if required) or trunk test, respectively, a path is closed from ground on the operated contacts of the FO-3 relay to the armature of the TM4 interrupter. This path is put through the break contacts of the TG-6 relay in order to cancel this check circuit anytime the TG-6 relay operates.

The TM4 interrupter B contact closes for .089 of a second, then there is an open period of 3.014 seconds, the F contact then has a closure for .101 second and then an open period of .022 second, this being a complete cycle. If when the TM4 interrupter is grounded, the B contact is closed, the TG-5 relay operates and locks, otherwise the TG-5 relay will await its closure.

Assuming that TG test does not take place due to an open trunk and the TG-2 relay does not operate, the first B contact closure of TM4 interrupter operates the TG-5 relay which locks, and three seconds later the F contact closes operating the TG-4 relay which locks. The TG-4 relay, in operating, grounds to TGF lead to the marker connector and releases the DST relay. The DST releases the DRL relay which releases the selection register relays and other relays which puts the sender back to the point for seizure of a marker. The TG-4 relay also causes the release of the TG-3 relay. The TG-3 relay is slow releasing to allow time for the sender to reset itself before selecting a second marker.

When the TG-3 relay finally releases and reoperates the DST relay, which regrounds the ST lead to the marker connector, a marker is seized with lead TGF grounded. The marker in receiving the grounded TGF lead will not function normally, but instead will call in the trouble indicator to take a record which will aid the maintenance force in locating the open trunk or channel. The marker will then send back a trouble release to the sender by grounding the TRL lead. The sender now functions as previously described for "trouble release in first trial."

Whenever the TG-2 relay is operated, it operates the TG-6 relay or should the sender advance for a second trial, the TR-2 relay operates the TG-6 relay. The TG-6 relay, when operated, locks and opens the path for grounding the TM4 interrupter, thus cancelling this check feature. The TG-6 relay, in operating, always releases the TG-3 relay.

The open trunk test feature can only be made once during a sender call.

FALSE REGISTRATION

In case more than two digit register relays are operated, due to a false ground or a short-circuit in the sender, the call will not be interrupted in its registration from the receiver. But when connection is made to the marker with three or more register relays operated for one digit, a false registration is connected over the register leads. This will cause the marker to block and a trouble indicator record will be recorded followed by a trouble release to the sender.

OVERFLOW AND TELLTALE

This section describes the action taken by the sender in case it receives reversed battery coming in over the fundamental in any position of the sender except incoming advance during a full selector call to a crossbar or panel central office. It may be caused by an incoming selector in a panel office running to overflow because all final selectors are busy or an incoming or final selector running to telltale because of trouble, or by a crossbar terminating sender running to telltale, or by a trunk to P.C.I. or operator having its conductors reversed. Briefly stated, the action of the sender is to put the offending selector or terminating sender in a position to return to normal; to restore the selection register and selection sequence circuits to normal in the M.F. sender; to break down the connection forward and call in a marker for another trial.

The action of a panel selector, terminating sender or revertive pulse tandem sender when it runs to telltale under different conditions, in general, it connects reversed battery to the fundamental. It then recognizes a closure and connects direct battery and ground to the fundamental followed by a second closure commonly known as trunk closure and then it returns to normal.

In some cases the distant circuit holds the reversed battery on the fundamental for a definite time after recognizing the first closure and then it breaks off of its own accord. In other cases, it holds it on until the sender breaks the fundamental closure. In "office telltale," "office overflow," and "incoming brush telltale" the sender does not wait for the opening of reversed battery. On incoming group and final selections, whichever condition occurs, the sender waits for the opening of the reversed battery.

TWO WIRE OFFICE OVERFLOW (P.C.I. CALL)

OF & OF-1

If a distant office selector runs to overflow in hunting for a P.C.I. trunk or if a trunk to P.C.I. which has its conductors reversed is seized, the sender at that time will be in trunk test position with TG and OF in the fundamental. They will both operate on the reversed battery.

The TG relay operates the TG-1 and TG-2 but has no effect since the OF-1 relay, in operating, breaks the AV relay operating path and immediately releases the TG-2 relay. The OF relay, in operating, locks.

The locking path is from ground on its make contacts, 22 to 35 lead, 35 to 32 lead, break contacts WU, 2 to 33 lead, 33 to 36 lead, break contacts SS-5, 14 to 24 lead, winding OF, break contacts AV-1, make contacts DST, to battery.

The closing of the OF contacts, operates the OF-1 relay. The path for the OF-1 relay is the same as above to lead 14, it then follows, 14 to 31 lead, 31 to 34 lead, make contacts S-6', break contacts FS-1, to winding of OF-1 relay.

IA

The operated OF-1 relay closes a circuit to operate the IA relay. The operated IA short-circuits the TG relay, releasing it, and this lowers the resistance in the fundamental in order to operate a relay in the distant office selector circuit. The TG, in releasing, releases the TG-1 relay.

The early closing bottom front contacts No. 3 and No. 4 of the IA relay are ineffective because the STP relay is not operated, but the late closing bottom contacts No.1 and No. 2, operate the 0 counting relay through a front contact of the TCI, OF-2 and OF-1 relays. The operated OF-1, releases the OF-2 relay, which is slow in releasing to allow time for the 0 counting relay to operate, then for the BO and FO to operate upon its release. The fundamental thus remains closed during the release time of the OF-2 relay, thereby insuring the operation of relays in a two wire office or a distant tandem revertive pulse sender for their release. The BO relay opens the fundamental and the FO relay operates the FO-1 and FO-2 relays. The FO-2 relay operated, releases the FO-3 which releases the 0, BO, FO, FO-1 and FO-2 relays.

AV-2

When the FO-2 operated, a path was closed to operate the AV-2 relay, which locks, and this starts the trunk closure cycle followed by the recall of a marker, as described later.

TWO WIRE OFFICE OVERFLOW (PANEL CALL)

If a panel office selector runs to overflow in hunting for an incoming selector, the sender at that time will be in trunk test position with the TG or MTG relay and the 14,500-ohm resistance in the fundamental. The OF relay is short-circuited to prevent its possible operation at this time when the fundamental bridge is too high in resistance to be recognized by the distant circuit as a closure.

STP & OF

The TG or MTG relay will operate on the reversed battery and the sender will advance to the incoming brush position where the STP and OF relays are in the fundamental. They will both operate on the reversed battery. The OF locks and operates the OF-1 relay through the break contacts of the S-6', SS-5 and WU relays. The OF-1 closes a circuit to operate the IA relay. The early closing front bottom No. 3 and No. 4 contacts of IA now operates the 0 counting relay, due to the STP contacts being closed. After a short interval, slow releasing OF-2, its operating path being broken by the operation of the OF-1, releases and breaks the circuit from the contacts of the STP, thereby allowing the BO and FO relays to operate.

The BO relay opens the fundamental releasing the STP relay, and the FO operated starts the same train of relays, as previously described, to the release of the FO-2 relay.

PANEL INCOMING SELECTOR OVERFLOW
TWO WIRE OFFICE SELECTOR TELLTALE
INCOMING & FINAL SELECTOR TELLTALE
CROSSBAR TERMINATING SENDER TELLTALE

If a panel incoming selector runs to overflow in hunting for a final selector, or if an office, incoming or final selector, or crossbar terminating sender runs to telltale, the sender at that time will be in some selection position with the STP and OF relays in the fundamental.

STP & OF

Both these relays operate when reversed battery is received for any of the above conditions. The OF relay locks and it operates the OF-1 relay, through break contacts of S-6', SS-5 and WU relays, as previously described. The OF-1 closes a circuit to operate the IA relay. The early closing make contacts of IA operates the O counting relay and when the distant selector breaks off the reversed battery, the STP relay releases. The OF-2 relay releases upon the operation of the OF-1 and depending on whether the STP or OF-2 relay releases first, the path for short-circuiting the BO and FO is opened allowing these relays to operate.

The late closing front contact of the IA relay serves to insure the operation of the O, BO and FO relays in case of a very short pulse of reversed battery, from ground cut-off incoming selectors, as described in a regular call for incoming advance.

The FO relay, in operating, starts the same train of relays as previously described, to release of the OF-2 relay.

DISTANT OFFICE TRUNK CLOSURE DURING OVERFLOW

When the FO relay operates in any of the conditions described in the preceding subsections, it operates the OF-1 relay through make contacts of OF-1 relay. The FO-1 operates the FO-2 and that releases the FO-3. The FO-2 breaks the fundamental, if the BO has not already done so, to give the signal required in some cases for the distant selector to apply a straight battery closure.

The FO-2, in operating, operates the AV-2 relay, which locks up. The operation of the AV-2 and the release of the FO-3, removes all grounds holding the O, BO and FO and they release. The release of the FO relay is followed by the release of the FO-1 and FO-2.

The operation of the AV-2 and the release of the FO-2 bridges the 500-ohm AA resistance, across the FT and FR to serve as the trunk closure to the distant selector or sender and breaks off the FT lead from the fundamental circuit to prevent STP or TG from operating on this trunk closure.

AV-3

The release of the FO-2 relay, after the operation of the AV-2 relay, opens the operating circuit of slow releasing relay AV-3, which releases. The AV-3 relay is slow release to allow an interval of time for the trunk closure to be effective.

Since trunk closure is not required for step-by-step class calls, this feature is omitted by the operation of the SOF relay, which prevents the AV-2 relay from operating. The SOF, in operating, allows for a marker to be recalled immediately.

The release of the AV-3 relay with the AV-2 relay operated following trunk closure operates the TR-1 or TR-3 relay. This causes the release of the DST and DRL relays, all selection register relays locked to DST, and all relays fed by off-normal battery including the OF relay. The OF releases OF-1, which in turn, releases IA and AV-2 and the release of AV-2 removes the ground shunting the TR-2 or TR-4 relay. The marker is then called in for a second or third trial, as previously described.

ABANDONED CALLS

This section describes the procedure in case the T and R leads are opened by the originating office before the sender has completed its normal functions on a call. If the train of connections to the called line has been partly built up, it is necessary that steps be taken to restore all selectors to normal. The procedure depends upon the class of call and the stage to which it has advanced when it is abandoned.

LR-1, LR-2 & LR2A

When an abandoned call takes place in the originating office and the T and R leads are opened, releasing the L relay long enough for the slow releasing SR relay to release, a circuit is closed to operate the LR-1 relay. The SR relay releases the SR-1 and together with the LR-1 relay operated, closes a path to operate the LR-2 relay. Both the LR-1 and LR-2 relays lock. The LR-2 operates the LR2A and also the STC relay as if registration has been completed. The LR-1 relay opens the operating path for the SR relay and also releases the RV-2 relay, if operated, to insure a stop pulsing signal in case the trunk is reseized after the call is abandoned. The functions of the LR-1, LR-2 and LR2A relays depends upon the condition of the sender as described in the following sections:

BEFORE MARKER IS ENGAGED

If the call is abandoned before the sender has engaged the marker, no connection has been made through the switches and there is no reason why the sender should not be disconnected at once. If a marker has been used and dismissed but the DRL relay is momentarily normal, preparatory to a second trial caused by an overflow condition or trouble release, there may be a connection built up to a distant selector, but this selector has been put in condition to return to normal so it is still true that the sender may be disconnected at once.

If the DST relay has been operated but due to marker delay, no marker has been engaged, the holding ground for the SR-1 relay is not closed in the marker connector and the SR-1 relay is permitted to release. When the SR-1 relay releases, the LR-2 relay is operated, which removes battery from the CBS lead to the connector. With the LR2A operated and the DRL normal, a path is closed to operate the AV relay.

WHILE MARKER IS ENGAGED - OR AFTER MARKER IS ENGAGED - ON CROSSBAR OR PANEL CALL

When a marker is engaged for a call, it operates the DC relay; then operates the DRL relay, then established connection to a trunk, and finally releases the DC relay. Until the marker connector is released, the LR-2 relay cannot operate because the SR-1 relay is being held operated. After the connector releases, the SR-1 releases and operates the LR-2, followed by the LR2A relay.

With the DC released, the sender completes any distant office selections in the route, makes trunk test and attempts incoming brush selection; or if the call has progressed beyond that point before being abandoned, it attempts the next selection in order. Neither trunk test nor any selection is delayed for registration because the paths which ordinarily delay the release of the FO-1 and FO-2 relays are opened by the operation of the LR-2 relay.

When the SR-1 relay released, the top No. 3 and No. 4 contacts open the counting relay path, through the STP relay for operating the No. 0 counting relay on an incoming or final selection, so the attempt to make such a selection sends the selector to telltale. These SR-1 relay contacts do not have any interference with the selections to a distant office selector or a second tandem R.P. sender.

OF

The distant incoming or final selector going to telltale sends a pulse of reversed battery over the fundamental, the sender recognizes it by operation of the OF relay, and then the sender makes trunk closure.

On a reversed battery signal caused in any way except by an abandoned call or a timed-out sender (as described later) the trunk closure is followed by the recall of a marker to make another trial. With the LR-2 relay operated, however, the release of the AV-3 with the AV-2 relay operated, causes the AV to operate, and to release the sender.

AFTER ASSIGNMENT OF A P.C.I. CALL WITH THE TW RELAY OPERATED

On abandoned P.C.I. calls where the TW relay is operated; in order to restore any distant office selector or release a tandem R.P. sender which may have been seized or to satisfy a P.C.I. operator who may have been signalled, the sender is allowed to proceed with its regular functions to the end, but as far as possible zeros are substituted for the registered digits in the transmission of P.C.I. pulses.

The sender completes any distant office selections in the route, makes trunk test, awaits assignment and then sends out the PCI pulses and operates the AV relay in the usual manner. Trunk test is not delayed for incomplete registration because the operation of the LR-2 opens the path which delays the release of the FO-1 relay. All digits transmitted after the operation of the LR2A relay are sent as zeros because the operating paths for the PT and PR relays are opened by the contacts of the LR2A.

If registration has not progressed far enough to operate either the STA and STA' or the STB and STB', the latter pair will be operated through the make contacts of the CI relay and the back contacts of the STA' relay. This is to prevent the sending of nine digits by the double registration of stations.

If the assignment should be delayed to such an extent that the sender reaches the stuck sender position, as described later, on an abandoned call with the TW operated, the AV relay will then be operated from break contacts SR-1, make contacts TG-1, CI and TN, to off-normal ground.

BEFORE ASSIGNMENT OF A PCI CALL WITH THE TW RELAY NOT OPERATED

If the call is not routed through a distant office selector, and has reached the awaiting assignment position or it has not reached the awaiting assignment position but has received the office code which will advance it to awaiting assignment, in either case the operation of the TG-1 relay with the SR-1 relay released causes the sender to release immediately. The release of the SR-1 operates the AV relay, through its bottom No. 1 and No. 2 contacts, make contacts TG-1, CI and TW, make contacts S-6', to off-normal ground. This is to extinguish the trunk lamp at the operator's position as soon as possible.

RELEASE OF ABANDONED CALLS

When the AV relay operates in any of the previously described abandoned calls, it operates the AV-1 and AV-2 relays. The AV-2, in operating, starts the release of the AV-3 relay and connects the 500-ohm AA resistance across the FT and FR leads for distant office trunk closure. When the AV-3 relay has released, it operates the AV-4 relay, followed by the release of the CK-4 relay. The operation of the AV-4 relay opens the CO lead to restore the trunk. When the CK-4 has released, it opens the holding circuit placed on the ON-2 and ON-3 relays by the make contacts of the LR-1 relay. The release of the ON-2 and ON-3 relays, return the sender to normal.

SENDER RESEIZED WHILE STILL ENGAGED AFTER AN ABANDONED CALL

If the sender is reseized during the process of restoring, after an abandoned call, it is necessary to prevent the transmission of a false start pulsing signal during the release of the sender. In order to accomplish this, on calls from No. 4 toll senders, the locking circuit for the RV-1 relay is taken through the particular CS- relay, preventing its release when the LR-1 relay operates, until the sender restores the trunk apparatus. On other classes the RV-1 relay is released when the LR-1 relay operates to restore the normal battery and ground polarity to the T and R leads and then the sender restores the trunk apparatus before the T and R leads are opened. To accomplish this the RV is cross-connected to RVO - RV4.

STRAIGHTFORWARD CALL ABANDONED

The sender simulates trunk test for a local straightforward call and that operates the AV relay in the usual way. The AV-2 operates followed by the release of the AV-3, which operates AV-4. Simulated trunk test is not delayed for dialing because the path which ordinarily delays the release of FO-1 is opened by the operation of LR-2 relay.

For straightforward class through a second tandem, the call is allowed to proceed with trunk test followed by trunk closure in order to restore the tandem apparatus. When trunk closure is completed, the AV-3 releases and AV-4 operates to restore the sender.

TIMING CIRCUIT

This section describes the timing circuit and the procedure in case of a permanent signal from the originating office, partial registration, stuck sender, waiting assignment, and the timing in connection with reorder flashes sent to the originating end as a result of operation from the "operator's error" relay OE, or from the "reorder" RO relay. Time is measured by the timing interrupter TM2 which has a 20-second cycle, closing its contacts for 10 seconds and breaking them for 10 seconds.

MEASUREMENT OF TIME INTERVALS

TM-1 & TM-2

Whenever ground is connected to the TM2 interrupter, the TM- relays being normal, the TM-1 relay operates at once or as soon as the interrupter closes. The TM-2 operates on the following first break. The TM-1 releases on the second closure and the TM-2 releases on the second break. This 40 second-cycle repeats as long as the interrupter is kept grounded.

TM-3 & TM-4

The TM-3 and TM-4 relays are actuated by a make contact of the TM-2 relay. The TM-3 relay operates in from 0 to 20 seconds after the connection of ground to the interrupter. The TM-4 relay operates 20 seconds later and locks up, and the TM-3 relay releases after 20 seconds more.

The ground connected to the interrupter is also the locking ground for the TM- relays and whenever it is broken all the operated TM- relays release.

TIMING FOR REGISTRATION TO START

When the sender is seized, the timing circuit starts to measure a period of from 20 to 40 seconds. If the first digit is registered in that time, the timing circuit is restored and starts again. Otherwise, a flash is returned for 10 seconds and then the trunk is set in the "no connection" condition and the sender is dismissed. If the sender fails to release within 10 seconds, the stuck sender lamp is brought in. The "no connection" condition is to operate the trunk D and D-1 relays with no channel crosspoints closed, with the A relay remaining operated.

The interrupter is connected to an off-normal ground lead through the break contacts of relays AL-1 and STS, and when the ON-1 relays ground that off-normal lead, the TM- relays start to function.

If the digit is registered in time on the A digit register relays, the AL-1 relay operates and locks up for the remainder of the connection. The AL-1 removes ground from the TM2 interrupter and any operated TM- relays thereupon release. When the TM- relays are normal, a path is closed to operate the AL-2 relay and it locks up for the remainder of the connection unless the STS relay should be operated.

REG & TN

If the A digit is not registered in time, the TM-4 relay operates and locks, operates the REG relay and that, in turn, operates the TN relay. The TN relay locks and closes battery to the FL interrupter. The PU-1 and PU-2 relays function as previously described under "reorder." The TN releases REG.

When the TM-3 relay operates with the AL-1 relay normal, an additional ground is connected to the TM2 interrupter, from the break contacts of the TM-6 relay.

STS

If the sender is not released 10 seconds after the REG and TN operate, the TM-1 will operate and the STS then operates through break contacts AL-2, make contacts TM-1 and TN. The STS locks and operates the AV relay. If the sender fails to release as a result of AV operating, an additional 10 seconds are counted and then the TM-2 operates, shunting down the TM-3 relay. The bottom No. 4 and No. 5 contacts of the TM-3 opens the ground to the TM2 interrupter and at the same time releases the TM-1, TM-2 and TM-4 relays. The TM-4 grounds the A and L leads to the miscellaneous circuit for sender make-busy frame, causing an audible and visual alarm, and lighting the stuck sender lamp, respectively.

TIMING FOR REGISTRATION TO FINISH

When the first digit has been registered, the timing circuit starts again to measure a period of from 20 to 40 seconds, for digit registration to be completed. If the units digit is registered in that time or the office code indicates no further registration, the timing circuit is restored and starts again.

When relay AL-2 operates on the restoration of the timing circuit after the registration of the first digit, it grounds the TM2 interrupter through a break contact of the UL-1 relay. This starts the TM- relays on another cycle.

The operation of the STC relay signifies the completion of registration. The UL-1 relay operates from a make contact of STC and a break contact of LR-2, to stay for the remainder of the connection. The UL-1 breaks ground from the interrupter and any operated TM- relays are released. When they are all normal, the UL-2 relay operates to lock up for the remainder of the connection unless STS should operate.

REG & TN

If registration is not completed, in time the TM-4 operates and locks, and causes the REG to operate. The REG, in turn, causes TN to operate and send reorder. The REG, in operating, grounds the AR lead to the miscellaneous circuit for sender make-busy frame because of the AL-2 operated. This causes the partial registration register to operate when the REG relay releases. The TN, in operating, releases the REG. The timing continues and if the originating end does not disconnect and release the sender in 20 seconds, the following action takes place.

LR-2 & LR2A

The reoperation of TM-1 and TM-2 at the end of this additional 20 seconds causes the LR-2 to operate because of the AL-2 and TN relays are up. The LR-2 operates the LR2A. This results in the operation of the AV relay and the disconnection of the sender under various conditions as follows.

The operation of the LR-2 simulates the completion of registration by operating STC. The LR-2, by opening the top No. 1 and No. 2 contacts, prevents the seizure of a marker if it has not already been connected; LR-2 will release the marker connector if it is still attached. If the DRL relay is not operated, no outgoing trunk connection has been made, and AV is operated immediately from make contacts of LR2A and break contacts of DRL. All partially registered codes including operator codes, disconnect in this way.

On an out-dial pulse class call, the AV is operated immediately from make contact of SS and LR2A.

On panel or crossbar calls, the sender completes any distant office selections in the route. Any delay features required for incoming and final selections take place as far as registration has been completed. When the time-out occurs, the LR-2 relay, in operating, opens these paths and will release the FO-1 and FO-2 relays, thus allowing the incoming and final selections to continue. However, at some point the incomplete digit registration will result in failure to close a counting relay path for some selection, and the panel selector or crossbar terminating sender will be sent to telltale. The resultant reversed battery signal from the terminating end operates the OF and STP, which operates the OF-1 and FO. This causes the operation of AV from ground on make contacts FO, break contacts SS-1, make contacts OF-1, break contacts LR-1, make contacts LR2A, to winding of AV. This condition differs from the action of an overflow or telltale due to trouble, in which case the FO-2 operated and causes the operation of AV-2 for a second trial, as previously described.

On a call indicator class, the AV relay is operated after all PCI pulses are sent as previously described for abandoned calls.

The operation of the AV relay, as described for this timeout, causes the AV-1 to operate. This operates the trunk D relay, and the sender disconnects as on a completed call. The trunk provides the trunk closure for any terminating trunk connection which may have been set up.

STS

If the sender is not released in 10 seconds more, the TM-1 releases and operates the STS relay. The STS provides another path for the operation of the AV through the break contacts of UL-2 and CP relays.

If the sender is not released by the operation of STS, 10 seconds later the TM-2 releases, which releases the AL-2 and all the TM- relays, and lights the stuck sender lamp through the break contacts of TM-4 and make contacts of STS.

TIMING FOR CALL TO BE COMPLETED

When registration has been completed the timing circuits starts again to measure a period of from 20 to 40 seconds unless the call is routed through a distant office selector or a R.P. tandem sender when the period measured is from 60 to 80 seconds. If the call is not disposed of, the sender transmits reversed battery flashes to the originating end for 20 seconds.

When the UL-2 relay operates on the restoration of the timing circuit after the completion of digit registration, it grounds the interrupter and so starts the TM- relays on another cycle. If the TW relay is operated, the time counted before the TN relay is operated, is extended from 60 to 80 seconds.

STUCK SENDER TW OPERATED

On this cycle of timing for the disconnection of the sender, the TM- relays operate as follows: In 0 to 20 seconds TM-1, TM-2, and TM-3 are operated. In 20 to 40 seconds TM-1 and TM-2 are released and TM-4 operates. In 40 to 60 seconds, TM-1 and TM-2 are operated again, and TM-3 releases. In 60 to 80 seconds, TM-1 and TM-2 release for the second time, but TM-4 is locked to the timing ground lead. At this point, then TM-2 and TM-3 are released, and TM-4 is operated, which provides a path for the operation of the REG relay, which operates the TN relay. The TN relay causes reorder flashes to be sent to the originating end, as previously described. The operation of the REG relay connects ground from make contacts of UL-2 to the SS lead of the miscellaneous circuit for sender make busy frame to operate the stuck sender register.

If disconnection of the originating end does not take place, the timing continues, and 20 seconds after the TN operates the TM-1 and TM-2 relays are both operated again, which causes the LR-2 relay to operate. This results in the operation of AV and disconnection of the sender as previously described.

If the sender is not restored to normal in 10 seconds more, then STS relay operates. When the STS relay operates on a stuck sender condition, with the UL-2 relay operated, it closes a path for operating the AV relay through the sender, cancel priming key normal. This path is traced from battery winding of AV to the CP2 lead, to the miscellaneous circuit for sender make-busy frame, through CP key normal to CP1 lead, make contact UL-2, break contacts CP, make contacts STS to off-normal ground.

If the sender still fails to return to normal, then 10 seconds later the stuck sender lamp is lighted by the TM-4 relay releasing and connecting ground to the L lead.

STUCK SENDER TW RELEASED

If the TW relay is not operated, the result of the timing relay operations depends on whether the call is a call indicator or a non-call indicator class.

On a non-call indicator class, the TM-1 and TM-2 relays are first operated and then released in a 20 to 40-second interval, the TM-4 operating when the TM-2 releases. This operates the TN relay to flash the originating end. If the sender is not released at the end of another 20 seconds, the LR-2 relay operates with subsequent operation as previously described.

TM-5 & TM-7

On a call indicator class call, the completion of digit registration is followed by trunk test, and then the sender is in the waiting assignment condition. In this condition, the UL-2, CI and TG-2 relays are up and close a circuit to operate the TM-5 relay. This switches the timing circuit from the break contacts of the TN relay for operating the REG relay to the winding of the TM-7 relay. When 20 to 40 seconds are counted the TM-4 relay operates the TM-7 relay. This path is through the make contacts TM-5, break contacts TW, make contacts TM-4, break contacts TM-7, make contacts UL-2, break contacts STS to off-normal ground. When TM-7 operates, it locks directly to the STS relay. With the TM-5 and TM-7 relays both operated, ground is connected to the L1 lead, to the miscellaneous circuit for sender make-busy frame, lighting the SC lamp as an indication of slow assignment on a PCI call.

TM-8 & TM-5

The TM-7, in operating, releases the TM-3 and TM-4 relays, and removes ground from the TM2 interrupter. With the TM-1 to TM-4 relays released, a path is closed to operate the TM-8 relay, from battery on its winding, make contacts TM-7 and UL-1, break contacts TM-1, TM-2, TM-3 and TM-4, make contacts AL-1, break contacts STS, to off-normal ground. The TM-8 relay locks.

When assignment is made, the release of the TG-2 relay releases the TM-5 relay, thus causing the sender to resume its timing. If the sender fails to return to normal in 20 to 40 seconds, the TM-4 will then cause the REG and TN to operate. Operation of TN causes reorder signal with subsequent operation as previously described.

SHORT SENDER TIMEOUT

If there is a plug in the ST jack at the sender make-busy frame, ground will be connected to the ST leads of all associated senders and terminate at the top No. 7 contact of the TM-7 relays.

TM-6

If a sender now timeouts in 20 to 40 seconds due to awaiting assignment, the operation of the TM-7 relay, through the make contacts of TM-5, operates the TM-6 relay. The TM-6 locks and immediately operates the AV relay which releases the sender as on a completed call.

The operation of the TM-6 releases the TM-5, and the operation of the TM-7 releases the TM-3 and TM-4. This closes a path to operate the TM-8 and start a new timing cycle. If the sender does not release in 40 seconds, the REG and TN are operated. Operation of TN immediately operates the STS through the make contacts of the TM-5 relay. The STS, in operating, releases the TM-4, TM-7 and TM-8, and the UL-1, UL-2 and AL-2, if any of these relays are operated. With the STS operated and the UL-2 relay released, another path is closed for the AV relay through break contacts of the CP relay. The SS lamp is lighted from the break contacts of TM-4 and make contacts of STS as a stuck sender signal.

AUTOMATIC PRIMING OF STUCK SENDER CANCELLED

CP

If it is desired to cancel the automatic priming feature for stuck sender conditions, and to trace trouble, the cancelled priming key is operated at the sender make-busy frame.

With the key normal, the CP1 and CP2 leads are connected together, and the CP3 lead to the CP relay is held open by the insulating area of the key. When the key is operated, the CP2 lead is insulated and the CP1 and CP3 leads are connected together. This opens the operating path for the AV relay from the make contacts of STS, break contacts of CP and make contacts of UL-2. Instead, the CP relay winding is connected in place of the AV relay.

If all digits have been registered as indicated by the operation of UL-2, then when the sender reaches the stuck sender position, the STS operates, in turn, operating the CP relay. The CP operated, locks under control of the cancel priming key, opens the S lead to the link hold magnets, thereby breaking down the connections between the trunk and the sender. The sender is held and the stuck sender lamp is lighted.

If the stuck sender condition is reached but all digits have not been dialed, then AV operates through the break contacts of UL-2 and the sender releases just as though the cancel priming key had not been operated.

TIMING OF REORDER FLASHES WITH OE OR RO OPERATED

The operation of the OE relay or the RO relay connects resistance battery to the FL interrupter. When the FL interrupter has timed-out its complete cycle operating the PU-1 and PU-2 relays, subsequent closures of the B contact causes a reorder flash to the originating office.

Unless the originating end disconnects within the timing cycle in progress, the timing circuit will function to release the sender by operation of the LR-2 relay, and if this fails, then the STS relay operates, and finally the SS lamp lights if no releases are effective.

SENDER MADE BUSY FOR MAINTENANCE

MB

The sender is made busy when it is in trouble or for other maintenance purposes by inserting a make-busy plug in the make-busy jack at the sender make-busy frame. This operates the sender MB relay over the MB lead. The MB relay grounds the SB lead to operate the SB relay in the sender selector circuit to indicate that the sender is busy, just as relay ON-1 would do in a regular call. The MB relay also connects resistance battery to the S lead to serve as a plugged busy signal to the sender test frame.

If the marker connector is made busy, the senders that are served by this connector are all made busy by grounding the MB leads from the connector. This has the same effect on each sender as inserting a plug in the make-busy jack.

The grounding of the SB lead when the sender is made busy not only prevents link circuits from seizing it but it also causes the BS lead to be grounded to the link controller circuit. In order that this shall not operate relay ON-2 or hold it up if the sender is plugged busy while engaged on a call, the BS lead is carried through a make contact of relay SR-1. This relay normally releases at the end of a call and ON-2 and ON-1 are therefore permitted to release.

SENDER SEIZED AND HELD FOR TEST

All the individual and common leads from the sender and the group of five senders which run to the sender link frame and controller circuit, except the individual leads SB, BS, HM and SC, are also multipled to the sender test circuit.

The test circuit seizes a sender for test in the same way that the sender link and controller seizes it for service, except that is demands connection with a particular sender instead of choosing an idle sender more or less at random. Before it can seize the desired sender, the latter must be idle and to determine this condition, it makes a test of the S lead which is not made in a service condition.

If the sender is engaged on a call, the S lead is grounded by the ON-2 relay being operated. If the sender is made busy, the S lead is connected to resistance battery at the MB relay.

The test circuit first tests the S lead for battery and then for ground. Finding neither, it connects to the sender; otherwise it waits until battery or ground disappears, unless it is set for pass busy.

When the test seizes the sender, the relays operate as on a service call.

RECEIVER BCO JACK

The BCO jack is provided to facilitate turning off the vacuum tubes when testing or adjusting the relays in the receiving circuit.

RECEIVER TEST JACKS

Jacks T1 and T5 are provided to facilitate testing the 239-type relays in this circuit. They make it possible to isolate each winding, or groups of windings in series, and to pick them up from the front of the frame.

M. F. SENDER
SD-25978

M. F. SENDER
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Multi-Frequency Sender
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MULTI-FREQUENCY SENDER CIRCUIT SD-25978-01

PURPOSE OF CIRCUIT

This circuit is used in a tandem crossbar office to complete calls from manual, D.S.A., and toll switchboard positions equipped for M.F. key-pulsing, or senders arranged to transmit multi-frequency pulses. It is used to complete calls to panel, crossbar RP, DP or MF terminating, crossbar R.P., D.P., or MF tandem, manual, step-by-step, and panel sender tandem offices; and to operator and desk positions.

Either two-digit or three-digit office codes, or both two and three-digit office codes from 20 to 99, or 200 to 999 (or their letter equivalents) may be used. For combined two and three digit codes the initial digit determines whether codes beginning with that digit are two or three-digit codes.

Any three-digit code from 200 to 999 may be used to reach operator or desk positions. In addition service codes from 100 to 109 and 120 to 199 are available; and either two or three-digit (not both)TX codes prefixed by 11 may be used, from 00 to 99 or from 000 to 999.

DESCRIPTION OF OPERATION

TRANSIENT CONNECTIONS TO OTHER CIRCUITS

Each group of senders is connected to the sender link and control circuit by a plurality of wires which are connected into any one individual sender for a short time when it is first seized for service. These are the "GS", "SL" and "RL" leads which assist the link control circuit in its functions; 12 numbered "F" leads for registering in the sender the number of the tandem trunk link frame; the class-of-service leads CS0 to CS6, and "HM" lead which supplies the initial operating ground for the sender link hold magnets.

Each sender is individually connected to the sender link and control circuit by 11 leads; "T", "R", "FT", "FR", "CO", "D", "DC", "S", "SC", "SB" and "BS".

Leads "T" and "R" are connected straight through the link switch contacts to the tandem trunk and serve to transmit multi-frequency pulses from the originating end, start-pulsing signals to the originating end, and to maintain disconnect supervision.

Leads "CO", "D" and "DC" are also connected through the sender link to the tandem trunk and serve for mutual control while the sender is engaged.

Lead "S" is connected through the sender link switch contacts to hold the switches operated while the sender is engaged.

Lead "SC" operates relays in the sender while the link control circuit is engaged in seizing the sender, principally for the purpose of connecting the common leads into the sender.

While the sender is either engaged or plugged busy it operates a relay individual to itself in the link control circuit over lead "SB" and that relay returns an indication of its own operation to the sender over lead "BS."

The sender is connected through the tandem marker connector to a tandem marker for a fraction of a second on each call. A plurality of wires are involved in this connection for mutual control and transmission of information in both directions.

Leads "FT" and "FR" are used for pulsing toward the called end; "DC" is used for mutual control between marker, trunk and sender; and lead "D" for sending a trouble release from the marker by way of the trunk or to signal the trunk to assume a cut-through position.

GENERAL METHOD OF OPERATION

When a sender is seized by a sender link and control circuit to serve a call, it immediately registers the class of trunk and the number of the trunk link frame involved by indications over the class-of-service leads and the "F" leads from the link control circuit. It then sends a "start-pulsing" signal and registers all the digits and a start signal pulsed over the "T" and "R" leads to the multi-frequency receiver circuit. When the office code is registered, the sender connects to a marker, sends it the office code, class of trunks, frame and other information and receives back such information as it requires for completing its part in the selection of the called station.

When the marker has established a connection through the trunk link frame and office link frame it notifies the sender and the sender proceeds. The sender first makes distant selections over the "FT" and "FR" leads if there are any such selections to be made, and then tests the outgoing trunk to make sure it is normal at the distant end for all classes of calls except local straightforward class. If the call is for a panel or crossbar office the sender directs the selections of incoming and final selectors or terminating sender, notes the incoming advance signal, all over "FT" and "FR" leads, advances the trunk to the cut-through position and releases itself from the sender link. If the call is a CI class the sender waits until the trunk is assigned at the distant end, then sends CI pulses over the "FT" and "FR" leads for the called station, or office code and station in case of a tandem call, advances the trunk to the cut-through position and then releases itself. On MF or SXS calls office selections are not made, but following trunk test one to eight digits are out-pulsed by MF or dial pulses, the trunk is advanced to the cut-through position and the sender releases itself.

If the called end returns a premature reversed battery because of a reversed trunk, telltale, or overflow the sender calls a marker again and notifies it to try again using a different trunk if possible.

If the call is abandoned the sender takes any necessary steps to clear out distant selectors and any CI equipment which may have been engaged, and releases itself from the sender link.

A timing circuit in the sender monitors its progress and initiates the proper disposition of the call, if no digits are dialed, if an insufficient number is dialed, if the trunk is open or if the call fails because of any other trouble condition.

SENDER SEIZED AND HELD FOR A SERVICE CONNECTION OS - 60,61

When a tandem trunk calls for a sender, the sender link control circuit chooses an idle sender and grounds its individual "SC" lead thereby operating relays (SC1) and (SC2). When operated, (SC1) connects common leads "SL", "GS" and "RL" into this sender and operates the (SR) relay by connecting ground through normal contacts of relays (PU2) and (LR1) to the winding of relay (SR). The (SR) relay is operated in this manner to prevent the link from timing out if the call is abandoned just after the link passes the point where it can recognize the wipe out and before the sender is in position to recognize it. The initial operating ground for (SR) is supplied from the link through the locking contacts of the class and frame relays.

The (SC1) relay also connects leads "CS0" to "CS6" for the operation of the proper class-of-service relay or relays from ground in the link, if any class of service relays are equipped. The ground is supplied in the link on the basis of trunk decades. No class-of-service relay is required if all trunks served by the sender group are of the same class with respect to the sender, and to the handling of terminating codes by the marker, as to routing, denial of service, or otherwise. If the marker is equipped with class relays and this sender group serves trunks of two or more of these classes, then relays (CS0) to (CS6) are equipped as specified in note 102 on the circuit drawing. If (CS5) and (CS6) are equipped, one of these two relays is always operated with any one of the (CS0) to (CS4) relays, to provide classes 0 to 4, or 5 to 9, respectively. If more than one of the (CS0) to (CS4) relays is operated, or if both (CS5) and (CS6) relays are operated, a path is provided to operate the (CHK) relay, from ground through contacts of the class relays to the secondary or primary winding of the (CHK) relay, respectively.

The class-of-service indication is transmitted from the sender to the marker by cross-connection of the CL0-9 and CG0-9 to the CS0-6 terminals as specified on Table of OS-60.

The RV0-9 terminals of the class-of-service relays are cross-connected as specified on Table of OS-60. This cross-connection is used for the special features specified, and also controls the tip and ring polarity of the sender on abandoned calls, to be the same as that of the trunk. This is necessary to avoid "pumping" reaction between the trunk and sender on abandoned calls, and also to avoid a false start-pulsing signal in case a trunk is reseized immediately after abandonment on a previous call.

The (SC2) relay contacts connect ground from the sender link to operate one of the frame relays (TF0) to (TF9), and either (TF00) or (TF10), corresponding to tandem link frames 0 to 9, or 10 to 19, respectively. If more than one of the (TF0) to (TF9) relays is operated, or if both (TF00) and (TF10) are operated, ground is connected through the contacts of these relays to operate (CHK) relay on its secondary or primary winding, respectively. The (TF-) relays lock through a normal contact of (AV1) to provide ample time for their release before the sender can be reseized.

After grounding the "SC" lead, the link control circuit operates the link switches which close eight individual leads to the sender. Seven of these leads "T", "R", "FT", "FR", "DC", "CO" and "D" are connected straight through from sender to trunk. The eighth lead "S", is connected to the hold magnets of the link switches.

The operating ground for the sender link switch hold magnet is closed to the sender over the individual "S" lead and back to the link control circuit over the common "SL" lead. Satisfied by this that the sender is ready for the next step and that the "S" lead is good, and after making a test to guard against a double connection, the link circuit then grounds common lead "GS" and so operates relay (On1) through a back contact of (CHK). If the (CHK) relay has operated due to operation of more than the correct number of frame relays or class relays, the operation of the (ON1) relay is prevented, causing the link control circuit to time out.

(ON1) relay contacts supply ground to off-normal ground leads, starts the sender timing circuit, to be described later; it also supplied GND to the armature of the operated (L) relay, through a back contact of (AV1). This will hold the (SR) relay operated after the link control circuit releases (SC1), unless the call has been abandoned, grounds the "CO" lead to the link to operate the (T) relay in the trunk to cut off the trunk (A) relay from the "T" and "R" leads.

(ON1) operated grounds the individual lead "SB" and that causes the link control circuit to ground individual lead "BS" to operate (ON2) and (ON3) in series through front contacts of (TF00) or (TF10), one of (TF0) to (TF9) relays, (CS5) or (CS6), one of (CS0) to (CS4) relays, and (SR1) relay. This operating path checks that a complete registration for frame number and class-of-service has been made, and that the (L), (SR) and (SR1) relays are operated.

(ON1) also connects tha two windings of the (L) relay to the "T" and "R" leads through the link to the trunk. This provides the path for holding the (L) relay, thus providing for control of disconnection in case of an abandoned call.

(ON2) operated connects ground to the individual "S" lead to hold the link switch hold magnets after the link control circuit has released, and it also grounds the common "RL" lead to release the link control circuit.

The release of the link control circuit breaks ground from the "SC" lead, and relays (SC1) and (SC2) release to break the connection of the common leads into the sender; but, the sender remains connected to the incoming trunk by the individual leads through the sender link switches until it has completed its work. Relays (ON1) and (ON2) lock each other up, ground off-normal ground leads to hold other relays, such as the class and frame relays, hold the sender link switches by grounding the "S" lead and guard against the intrusion of other links and the test circuit by grounding the "SB" lead.

(ON2) also closes a circuit through the back contact of (SR) to the winding of (LR1) so that the latter will operate to register an abandoned call if (SR) releases before the completion of a call, after having once operated.

M.F. RECEIVING CIRCUIT OS - 62, 62-1, 62-2

There are nine pentode beam-power type vacuum tubes in a receiving unit. The pentode vacuum tube is a five element tube, not counting the heater. There are six connections to a tube, numbered 2 to 8. The following is the association of the elements in this tube with the connection numbering.

Heater	#2 & #7
Cathode	#8
Control Grid	#5
Screen Grid	#4
Beam Forming Plate	(Connected to cathode)
Plate	#3

The vacuum tubes must be energized for the receiving circuit to be operative. They will normally be left on continuously except when the circuit is taken out of service.

The heater of the L1 and L2 tubes are wired in series and in parallel with the heaters of the 0 and 1 tubes which are in series. These tubes use A negative battery at the BCO jack to A positive ground through the H1, H2 and H3 resistances in series.

The heater of the 7 and 10 tubes are wired in series and in parallel with the heaters of the 2 and 4 tube which are in series. These tubes use B negative battery at the BCO jack to A positive ground through the H4, H5 and H6 resistances in series.

The heater of the SP tube uses the C negative battery at the BCO jack to positive ground through H7, H8 and H9 resistances in series.

The L1 and L2 tubes are wired for push-pull amplification and are known as the limited tubes. The plates of these tubes are receiving their positive potential from the L 54W coil, this coil functioning as an auto-transformer. Their screen grids have a positive potential, fed in a potentiometer arrangement from battery on the FLT repeat coil and ground on the P1 and P5 resistances.

The SP tube is known as the signal present tube, its screen grid having a fixed positive potential. The plate of this tube receives its positive potential from the T1 jack through the secondary winding of the SP relay causing this winding to be energized in the released direction during its statical period.

The 0, 1, 2, 4, 7 and 10 tubes are known as the channel tubes; the screen grids receiving their positive potential from the KP-2 and KP-3 relays while the receiver is locked or from the back contacts of their associated channel relay during the statical period after the receiver is unlocked. During the operation of the receiver these screen grids receive a lower positive potential through the primary windings of the CK-1, CK-2 and CK-3 relays. The plates of these tubes receive their positive potential through the secondary winding of their associated channel relay, thus energizing these windings in the release direction during their statical period.

The SP and channel tubes are operated as detectors.

The cathodes of all vacuum tubes in the receiver, receive their negative bias from the FLT repeat coil, this bias being shunted by a positive potential on the back contacts of the SP relay during the statical period.

The control grids of the L1 and L2 tubes are biased negative with respect to the cathodes during their statical period and the control grids of the SP and channel tubes, for all practical purposes, are at zero potential with respect to the cathodes in their statical period.

The filters 0, 1, 2, 4, 7 and 10 are band-pass filters, rated to pass their associated frequency, + or - 45 cycles.

BAT1, BAT2 & BAT3 LEADS

When the ON-3 relay in the sender operates, it connects battery to the BAT1, BAT2 and BAT3 leads to the receiving circuit.

The battery connected to the BAT2 lead is connected to the secondary windings of the CK-1, CK-2 and CK-3 relays in a parallel series circuit to ground at the T3 jack, energizing these windings in the release direction. These relays are biased polarized relays. The primary windings of these relays are connected in series from ground at the T3 jack to the network resistances 0B, 1B, 2B, 4B, 7B and 10B to battery on the BAT1 and BAT3 leads, these batteries being shunted by grounds on the back contacts of the KP-2 and KP-3 relays. Therefore, at this time there is no current flowing in the primary windings.

It should be noted that the battery on the BAT1 and BAT3 leads and the primary windings of the CK-1, CK-2 and CK-3 relays, together with the 0B and 0C to 10B and 10C resistances form a potentiometer circuit which becomes associated with the screen grids of the vacuum tubes 0, 1, 2, 4, 7 and 10. These batteries are connected in preparation for changing the screen grid voltage when the receiving circuit is in operation.

At this stage of the call, the receiving circuit is considered locked, for as long as the KP-2 and KP-3 relays are normal. ground on the break contacts of these relays are holding the screen grids of vacuum tubes 0 to 10 at normal potential.

The battery on the BAT2 lead is also connected to the primary winding of the KP-1 relay, this current being in the operate direction, although it does not operate the relay at this time. This is because the secondary winding is always energized while the receiving circuit is normal from battery on the T5 jack to ground on the break contacts of the 2 and 10 channel relays. The current in the secondary winding is in the released direction and always overpowers the primary winding while energized to its full value. It will be noted that the KP-1 and KP-2 condensers are short-circuited at this time by the same grounds that are energizing the secondary winding of the KP-1 relay. The KP-1 relay is a non-biased polarized relay.

TO

The TO relay is a non-biased polarized relay. The operation of the ON-3 relay energizes the tertiary winding to insure that the relay is on its back contact or during its releasing period to drive it down. A non-biased polarized relay has no coil spring to return the armature to its back contact when it is supposed to release, therefore, the tertiary winding is used for this purpose.

SENDER PREPARED FOR REGISTRATION OS - 60, 63, 64, 65

Eight digit registers of five relays each, such as the A0, A1, A2, A4, and A7, are provided for the A, B, C, D, E, F, G, H, digits. In some cases auxiliary relays are required to provide sufficient contacts, such as the AOA to A7A, DOA to D7A, IGH, E7A, FA5, AB5, BB5. In addition, provisions are made for the registration of the initial "1" associated with service codes through the use of the 11A and 11A' relays. "11" service codes are provided for through the use of 11B, 11B' and 11B2 relays; TX codes can be used if TXA, TXB and TXC relays are equipped.

The registration leads 0, 1, 2, 4 and 7 from the receiving circuit are transferred successively from digit to digit by means of a walking circuit consisting of a pair of relays per digit, such as AA and AB, BA and BB, etc., to HA and HB. These pairs of relays are all operated before registration starts, and are released consecutively as registration proceeds.

AA & AB

The operation of the ON-3 relay connects ground through back contacts of HA and AL-1 relays to the windings of the AB and AA relays in series, operating these relays; the AB locking and AA holding to the ON-3 grd. This off-normal ground is then connected to the windings of the BA and BB relays which operate. The process continues, the BB operating CB and CA relays, the CB operating the DB and DA. etc., until finally the HA and HB relays are operated. With the A and AB relays operated the 0, 1, 2, 4 and 7 leads from the receiving circuit are connected to the first group of sender register relays. Operation of HB relay, connects ground through RV2 and LR1 relays normal to operate RV1 relay.

START PULSING SIGNAL OS - 60

RV-1

From the beginning of the call, when the incoming trunk A relay is operated, until this point is reached, the originating office has been waiting for a signal to start pulsing. This signal is reversed battery, that is, battery on the ring and ground on the tip, from the M-F sender.

With the tip and ring of the incoming trunk now cut through to the tandem M.F. sender, the sender prepared for registration and the receiving circuit ready, the operation of the RV-1 relay causes the battery and ground on the windings of the L relay to be reversed and connected to the ring and tip, respectively, as the signal for start pulsing.

MULTI-FREQUENCIES OS - 62-1, 62-2

This type of call from an originating office to the tandem office is on a multi-frequency basis. This consists of transmitting two frequencies of various combinations for each digit required. Each multi-frequency call is preceded by a preliminary KP signal to unlock the receiving circuit. An ST signal is required because a call may consist of 3, 7 or 8 digits and follows the last digit required for particular class of call.

Three digits of only a service code is to be received, 7 digits consisting of an office code and 4 numerical digits if the call is for panel, crossbar or manual offices having no numbers over 10,000 and 8 digits consisting of an office code and 5 numerical digits if the call is to a manual office having numbers over 10,000 or party lines.

The multi-frequency signals may be sent out by an operator using a keyset which connects the proper frequencies for each digit to the trunk or by another sender. The two frequencies for each digit are received simultaneously. The multi-frequencies are a-c voltages, super-imposed onto the tip and ring d-c circuit, which is being supplied by the battery and ground on the M.F. sender L relay.

The signalling frequencies used for the multi-frequency pulsing are 700, 900, 1100, 1300, 1500 and 1700 cycles, which have been designated 0, 1, 2, 4, 7 and 10 respectively. Frequencies 0 to 7 are used for digit codes and frequency 10 is used in combination with frequency 2 for the KP signal and with frequency 7 for the ST signal. The following chart indicates the combinations used:

Frequency & Designation	Digit Codes											
	0	1	2	3	4	5	6	7	8	9	KP	ST
1700 (10)											X	X
1500 (7)	X							X	X	X		X
1300 (4)	X				X	X	X					
1100 (2)			X	X			X			X	X	
900 (1)		X		X		X			X			
700 (0)		X	X		X			X				

X Frequency Used

It will be noted from the above chart that the additive system is used for determining the two frequencies required for all digits except zero ST and the KP signal. For digits 1 to 9 the two frequency designations are added together by using the smallest combination for the addition. For digit zero, the KP signal and the ST signal they add up to 11, 12 and 17 respectively.

KP SIGNAL FREQUENCIES ON

When the receiving circuit IN repeat coil is cut through to a trunk or a keyset circuit at the beginning of a call, there is a brief period during which it may be exposed to speech or noise currents, which, if it were necessary to receive digit pulses, might cause false registration in the associated sender circuit. To prevent this, the receiving circuit is normally held in a condition wherein digits cannot be registered until after it has been unlocked by the functioning of the KP signal. This signal is composed of a relatively long period of frequencies 2 and 10, which must be on for the required time without presence of the other frequencies 0, 1, 4 and 7.

When the sender RV-1 relay operates and reverses the battery and ground, this is the signal to the No. 4 toll equipment, the No. 5 crossbar or the toll switchboard operator to start pulsing the frequencies.

L1 and L2 LIMITER VACUUM TUBES

When the KP digit frequencies are present in the primary coils of the IN repeat coil, they are induced into the secondary coils causing the L1 and L2 limiter tubes to amplify and limit the KP signal.

The L1 and L2 vacuum tubes are arranged for pushpull amplification, the 54W (L) retardation coil being used as an auto-transformer. In pushpull amplification each tube works on one-half of the a-c cycle, the other tube at that instant being cutoff.

The KP signal as amplified by the L1 and L2 tubes enters the L condenser and network resistances N1, N2, N3, N4 and N5. This output of the limiter circuit is divided into two parts by the resistances N1 and N2. The voltage across the N2 resistance is delivered through the network N3 and N4 resistances to the six channel circuits while the voltage across the N1 resistance is applied through resistance N5 and the IN filter to the primary coil of the SP input transformer.

The compensating filter CF is provided to improve the characteristics of the 700 and the 1700 cycle filters by simulating the effect which would be produced by adjacent filters below and above them, respectively. This is necessary to prevent a beat frequency.

SP CHANNEL VACUUM TUBES

Each plate circuit is connected through the bias winding of its associated polarized relay and the action is such that when signals are present, the plate currents in the tubes of the channels involved are decreased, thereby decreasing the current in the secondary or bias winding.

The control grids of the channel tubes in their static condition and for all practical purposes are at zero potential with respect to the cathodes. When a signal is applied to their control grids, each time they swing positive, the action is such that the current attempts to increase in the plate circuit but before this can happen the tubes reach their saturation point. Reaching the saturation point means that the tubes are conducting maximum electrons to the plate and cannot increase the current. When the control grids swing negative then the repelling effect of the electrons is such that the current is decreased in the plate circuit.

SIGNAL PRESENT CIRCUIT

The signal present circuit, consisting of the IN filter, the SP input transformer, the SP vacuum tube and the SP relay, is for the purpose of indicating to the receiver circuit when there is a signal present within the range of 700 cycles to 1700 cycles and of sufficient magnitude to be locked in. It is also for the purpose of preventing duplicate registration of a digit when the incoming signal is prolonged.

SP

The SP relay operates due to the decrease of current in its secondary winding, caused by the action of the plate current of the SP tube. The action of the SP tube is the same as previously described for the channel tubes.

With no signal present both windings of the SP relay are energized. The primary winding is energized from ground on the T2 jack to battery on the FLT repeat coil. The secondary winding is energized by supplying the positive potential to the plate of the SP tube and the tubes internal action. Since the primary winding is poled for operate and the secondary winding is poled for release, the secondary overpowers the primary until the current is decreased in the plate circuit of the SP tube.

The purpose of the SP retardation coil and the SP1 condenser is to reduce modulation products which would otherwise cause the SP relay to chatter. It also slows up the operate and release time of the relay by the charge and discharge of the SP1 condenser.

With the SP relay normal, the back contact is connecting a positive potential in parallel with a negative potential to the cathodes of the L1, L2 and SP tubes; the bias being more negative than positive and by this same circuit the L3 condenser is short-circuited. This holds the tubes to a definite limited output.

When the SP relay operates and removes this positive potential, the short-circuit is removed from the L3 condenser at the same time which charges and continues to hold a positive bias in the parallel circuit on the cathodes. When the L3 condenser is charged to the potential of the battery on the FLT repeat coil, there will be no further current flow in this leg of the circuit. When this point is reached, the cathode bias on the L1, L2 and SP tubes becomes more negative, thus increasing their sensitivity. This will cause a rise in the volume limiter circuit which will be sufficiently gradual by the L3 condenser charging to prevent objectionable transients.

2 & 10

The operation of the SP relay connects ground to the primary windings of the 0, 1, 2, 4, 7 and 10 relays in series but only the 2 and 10 relay can operate because of the decrease in current in their secondary windings. The primary windings in series are poled in the operate direction. The circuit is traced from filtered battery on the FLT repeat coil to the primary winding of the 10 relay in series with the 7, 4, 2, 1 and 0 relays, through the T1 jack, CH1 resistance, over the L lead to the sender, break contacts OE and ST relays, operated contacts RV-1 relay, break contacts TN and TO relays, operated ON-3 relay over J lead to receiving circuit, break contacts CK-1 relay, make contacts of SP relay to ground.

KP-1

The KP-1 relay is made slow operate by condenser timing for the purpose of insuring that the KP signal is present for its proper duration. The primary is the operate winding and the secondary the release winding. By the operation of the 2 and 10 channel relays, direct ground is disconnected from the secondary winding and the short-circuit is removed from the KP1 and KP2 condensers. Battery through the secondary winding then charges the KP1 and KP2 condensers, this charging current holding the KP-1 relay on its back contact. As the condensers become charged, this current decreases until the energy in the primary winding is greater than the secondary winding, thus causing the KP-1 relay to operate. The time interval in condenser timing is proportional to the capacity of the condensers being charged. In this case, the condenser capacity is approximately 8.62 M.F. which gives a time value of 48 milliseconds before the KP-1 relay operates.

It should be noted that on the KP signal only the 2 and 10 relays, both operated, can remove the short-circuit from the KP1 and KP2 condensers.

As previously stated, it is necessary that frequencies 2 and 10 be received for a definite length of time without frequencies 0, 1, 4 and 7 being present if the receiver is to be unlocked. If an impulse of one or more of these frequencies should appear at the same time as the KP signal, the corresponding channel relay or relays will operate and apply a short-circuiting ground to the KP1 and KP2 condensers. This will take place through the back contacts of the KP-2 and KP-3 relays. This will restore the full bias current to the secondary winding of the KP-1 relay releasing it immediately and discharging the KP1 and KP2 condensers rapidly. This restores the condenser timing in preparation for a new timing cycle, with the net result that the receiver remains locked until frequencies 2 and 10 appear by themselves for the necessary length of time.

KP SIGNAL FREQUENCIES OFF

When the KP signal is disconnected from the fundamental circuit, the L1, L2, SP, 2 and 10 tubes all return to normal. This means that their control grid bias and plate voltage return to their normal values. This will cause the plate current in the SP, 2 and 10 tubes to increase and place the normal bias on the secondary windings of the SP, 2 and 10 relays.

KP-2 & KP-3

The KP-2 and KP-3 relays will operate with the KP-1 relay operated and the release of either the 2 or 10 relay. While the signal present circuit causes the operation of the KP-1 relay, the 2 or 10 relay must return to normal in order to have an operating circuit for the KP-2 and KP-3 relays.

With the KP-2 and KP-3 relays operated, the receiving circuit is now unlocked. This is accomplished by the removal of ground from the OC to

10C resistances, allowing the ground on the back contacts of the 0, 1, 4 and 7 relays to have control. The grounds on the back contacts of all channel relays are now short-circuiting the primary windings of the CK-1, CK-2 and CK-3 relays.

0 TO 10 TERTIARY WINDINGS

The tertiary windings of the 0 to 10 relays are wired in series and are energized from the filtered battery on the FLT repeat coil to ground on the make contacts of the KP-3 relay. These windings supply a small additional bias to the 0 to 10 relays when the receiver is prepared to receive the numerical digits, but not when it is waiting for the KP signal. This bias is necessary to insure the release of relays after they have been locked up on digit codes as described later but is not needed when the KP signal is being received because by omitting this circuit a small increase in sensitivity is obtained.

KP-1 RELEASE

The top 4 and 5 contacts of the KP-2 relay causes the secondary winding of the KP-1 relay to be energized and the KP1 and KP2 condensers to be short-circuited. This causes the KP-1 relay to release and the discharge of the condensers but it does not interfere with the unlocking of the receiver because the KP-2 and KP-3 relays have locked up. The purpose of this arrangement is to make sure that the timing circuit is normal and ready to give a complete timing cycle on the next call without having to place any requirements on the open interval required between the calls.

A sequence adjustment is made on the contacts of the KP-2 relay to insure that the locking circuit, the top 10 and 11 contacts make ahead of the top 4 and 5 contacts that release the KP-1 relay.

The KP3 resistance is provided to insure that relay KP-1 shall always go to its back contact when the receiver is idle. If it were omitted, the removal of battery from the BAT2 lead during the time between the breaking of the back contact of relay KP-1 and the operation of relays KP-2 and KP-3, as might occur in an abandoned call, would leave the circuit blocked, since the condensers would be charged and there would be no current flowing in the secondary winding of relay KP-1 to release it.

REGISTRATION

The receiving circuit is now ready to receive the digit frequencies for the office code and numerical digits thousands, hundreds, tens, units and stations, which follow immediately after the KP signal. With the receiver unlocked and the KP-2 and KP-3 relays operated, the 0, 1, 2, 4 and 7 leads from the make contacts of their associated channel relays are cut through to the make contacts of the M.F. sender

AA relay to the windings of the A-0, A-1, A-2, A-4 and A-7 register relays. Each digit is registered by the grounding of two and only two of the five leads 0 to 7 from the receiver.

SIGNAL COUNTING AND SCREEN GRID LOCK

When the frequencies are connected for a digit of the office code or the called number, the receiving circuit functions the same as already described for the action of the L1, L2, SP and channel tubes. But since the receiver is now unlocked, there is a signal counting circuit consisting of the CK-1, CK-2, and CK-3 relays used to check for the proper number of frequencies and which incorporated a feature known as the screen grid lock.

When the two channel relays operate, the digit is locked in. This locking action is obtained in a rather unusual way by means of the vacuum tube circuits. When a channel relay operates, after the plate current flowing through its bias winding has been decreased sufficiently by the incoming signal, it removes its part of the short-circuit on the CK-1, CK-2 and CK-3 relays, and connects the screen grid of its associated tube to a potentiometer which supplies a much lower voltage than normal. This is accomplished by the removal of the grounds on the back contacts of the two channel relays to the screen grid of the associated vacuum tubes (+ voltage with respect to the cathode of the tube) and substitution of a reduced voltage obtained from the potentiometer made up of the associated resistances 0B and 0C to 7B and 7C, and the primary windings of the CK-1, CK-2 and CK-3 relays.

This causes the plate current on each of the two channel tubes involved to decrease below 3 mills and remain there, effectively locking up their associated relays until the operate windings (primary) are de-energized. The circuit remains in this condition even though the M.F. pulses from the originating end have ceased.

CK-1, CK-2 & CK-3

The signal counting circuit is provided for the purpose of recognizing that a correct digit signal, consisting of two frequencies and only two is being received after the circuit has been unlocked by the KP signal, while if an extraneous frequency should appear and operate one or more additional channel relays, a reorder signal is given as described later. Assuming that the correct signal has been received operating the two channel relays. These relays by removing ground from their back contacts open up their individual parts of the short-circuit on the CK-1, CK-2 and CK-3 relays. This allows current to flow through the primary windings of the CK-1, CK-2 and CK-3 relays.

The CK-3 relay does not operate in the series circuit as long as a combination of only two frequencies are received per digit. Should one or more additional frequencies be received, the removal of more than two of the grounds on the back contacts of the channel relays changes the balance in the potentiometer circuit, causing the CK-3 relay to operate. The CK-3 relay in operating grounds the RO lead for a reorder as described later. The CK-1, CK-2 and CK-3 relays serve to check the incoming signals and to tell the sender whether it should register a digit in accordance with the grounds on the 0 to 7 leads.

None of the CK-1, CK-2 or CK-3 relays will operate when only one channel relay is operated.

The make contacts of the CK-1 relay connects ground through the CH2 resistance, over the J lead to the sender, make of ON3 break contacts TO and TN relays, make contacts RV-1 relay, break contacts ST and OE relays, over the L lead to the receiver, CH1 resistance, to the primary windings of the channel relays, to hold these windings energized, in turn holding operated the two relays. The ground on the CK-1 relay replaces the ground from the operated contacts of the SP relay.

The purpose of adding the CH2 resistance to this circuit is to reduce the sensitivity of the channel relays somewhat, after two of then have operated, as a protective measure to reduce the likelihood of operating a third channel.

LOCKING IN REGISTRATION OS -63

The sender relays AA, AB, BA, BB, CA, CB, DA, DB, etc., are used as a walking circuit to transfer the receiving circuit registration leads from digit to digit as the call progresses. These relays are controlled by the operation and release of the CK-2 relay. Each time the CK-2 relay operates, it locks in the A relay and short-circuits the B relay of the group causing the B relay to release. Then at the completion of the digit, the CK-2 relay releases, releasing the A relay. The release of the A relay transfers the registration leads 0, 1, 2, 4 and 7 to the next group of register relays.

As the A relay releases after each digit registration, the make-before-break contacts top #1, #2 and #3, provide a locking circuit for the register relays. The #1 and #3 contacts lock in the register relays to off-normal ground at the ON-1 relay.

The ground from the make contacts of relay CK-2 insures that the digit will be registered correctly on short pulses due to the fact that the CK-2 relay is held up by the locking of the channel relays as already described, while the ground from the SP relay insures that there is no double registration in case the incoming signals are held on longer than the time actually required for registration. The signals must be present for at least 27 milliseconds.

CKA

The CKA relay is operated initially when the ON-3 relay operates and preceding each digit registration to provide a slight delay in closing the operating path for the TO relay. Thus, the CKA relay is slightly slow release to insure time for the receiver upon recognizing receipt of more than two frequencies to operate the CK-3 relay and ground the RO lead.

TO

The TO relay is marginal, operating only when two register relays have been operated and have closed their locking circuits. The battery through two or more secondary windings in parallel are closed by the B relay in the group of the walking circuit and the release of the CKA relay, are connected to the primary winding of the TO relay to ground on the break contacts of the CK-3 relay in the receiver circuit. In case one register relay only is operated, this locking circuit will not be closed and at the termination of the pulse, the operated register relay will release.

The TO relay receives its locking circuit from ground on the operated contacts of the CK-1 relay over the J lead.

The operation of the TO relay opens the operating circuit for the primary windings of the channel relays, which are now released by their tertiary windings. The release of a channel relay opens the screen grid lock.

CK-1 & CK-2 RELEASE

The release of either or both channel relays causes the release of the CK-1 and CK-2 relays. This is caused by ground being reapplied to the vacuum tube side of the corresponding OC to 7C resistances restoring the screen grid voltage to normal.

The release of the CK-1 relay opens the locking circuit for the TO relay but the operating circuit is not opened until the A relay in the walking circuit has released. When both of these circuits are opened the TO relay is released by its tertiary winding.

If at the time the CK-1 relay releases, the digit signal is still on holding the SP relay operated, ground will be held on the J lead by the SP relay, holding the locking circuit on the TO relay and preventing the J and L leads from being reconnected until the signal is off. The circuit is then ready for the next pair of digit frequencies.

REGISTRATION OF THREE-DIGIT OFFICE CODE

A-0 TO A-7 & A0A TO A7A

A 3-digit office code is registered on the A, B and C register relays. These codes are from 200 to 999, this being controlled by the fact that the alphabetical letters on the dial start in the second pull position of the dial. The A digit register relays A0 to A7 operate corresponding auxiliary relays A0A to A7A. These relays are necessary to gain additional switching contacts for grounding the proper combination of leads to the marker circuit and for P.C.I. pulses as described later.

It will be noted that the H lead closure from the receiving circuit for the A digit is different than other digits since it is closed to the AA relay by the prior operation of an A register relay. This slight delay is compensated for by making the A0 to A7 register relays fast-operate permalloy relays.

The operated A-0 to A-7 register relays are indicated below for all combinations of frequencies received in the A digit and represent the same numbered combinations for all succeeding digit register relays:

Digit	Relays Operated
0	A-4 A-7
1	A-0 A-1
2	A-0 A-2
3	A-1 A-2
4	A-0 A-4
5	A-1 A-4
6	A-2 A-4
7	A-0 A-7
8	A-1 A-7
9	A-2 A-7

AB-5

The AB-5 relay which is operated by the ON-1 relay is for the purpose of indicating to the marker whether the A digit of the office code is above 5 or below 5. The A register relays A0 to A7 by their combinations for digits 5 to 9 cause the AB-5 relay to release. On digits 2 to 4 the operating circuit for the AB-5 relay is not opened or a holding circuit is provided.

AL-1 & AL-2

The AL-1 relay is operated by one of the A0A to A4A relays when the A digit is registered. The AL-1 relay in operating causes the release of any time measure relays which might be operated, and disconnects ground from the TM2 interrupter. This ends the first timing period as described later, which started when the ON-1 relay operated.

When the TM- relays have released, a path is closed for the operation of the AL-2 relay. With the AL-2 relay operated, ground is connected to the TM2 interrupter for a new timing cycle as described later.

B-0 TO B-7 & BB-5

The B digit is registered on the B-0 to B-7 register relays. The BB-5 relay is operated from the ON-1 relay and may release or remain operated depending upon the digit registered. The BB-5 relay is for the purpose of indicating whether the B digit is above 5 or below 5. On digits 0 to 4, the operating path is not opened or a holding path is provided. For digits 5 to 9 the BB-5 relay is released by the combination of B-relays operated.

C-0 TO C-7 & CL

The C digit is registered on the C-0 to C-7 register relays. When the CA relay is released on the completion of the C digit registration, the CL relay operates. The CL relay receives its operating battery from the locking winding of the C-0 to C-7 relays operated and ground on the operated contacts of the ON-1 relay. The CL relay is for the purpose of indicating that the complete office code has been registered and that the call has progressed to the point of selecting a marker as described later.

TWO-DIGIT OFFICE CODES

Two-digit office codes are registered as follows: Any A digit 2 to 9 may be used as a two-digit code index. For such initial digit or digits the corresponding cross-connection terminals "L2" to "L9" are connected to terminal "TD." When a two-digit index is registered on the A-digit register, ground from the auxiliary A-register relays is connected through a back contact on the (BTR) relay and either a back or front contact on the (AB5) relay to the aforementioned cross-connection terminal. The "TD" terminal is connected through a back contact of (11A') relay to the (TD) relay, which operates and locks to off-normal ground. The (AB5) relay is pre-operated by off-normal ground supplied by the operation of the (ON1) relay before the "start-pulsing" signal is sent to the originating end. (AB5) remains operated if the A-digit is 0 to 4, but is released if the A-digit is 5 to 9. The (AB5) relay is fast-releasing, so that it will be released, if it is going to release, before the operating ground for the (TD) relay is supplied by the operation of the auxiliary A-digit relays (A0A) to (A7A).

The B-digit of a two-digit office code is registered on the B-digit register; but the operation of the (TD) relay releases the (CA) and (CB) relays so that the numerical digits fall on the same registers as for a 3-digit office code.

When the call is originated by a distant operator the (CS-) relay will ground the "RV-" punching which may be cross-connected to the "CTD" punching. The (CTD) relay operated, opens the operating path of the (TD) relay and connects it to the (TD1) relay. The distant operator must always key three digits in the office code. If the operator class relay is not cross-connected to operate the (CTD) (Cancel two-digit) relay, then the operator must dial two-digit or three-digit office codes as they are listed in the local area directory.

The (TD1) is operated so that on double-tandem operation a two-digit code will be transmitted as a two-digit code, even though three digits were registered by the distant operator. Either (TD) or (TD1) operated causes the out-pulsing steering relays for the C-digit (S3, S3') to be by-passed on out-pulsing.

SERVICE CODES

When the initial "one" of a service code is received the (11A) relay is operated from ground through the front contacts of the (A0) and (A1) relays. With this pair of relays operated the "H" ground is not connected through to advance the walking circuit by shunting down the (AB) relay.

Battery through resistance (Y), equivalent to two register-relay locking windings in parallel, is connected through front contact of (11A), back of (11A'), front of (A0) to the winding of (T0) relay, which operates. Operation of (T0) relay allows the channel relays to release, and they release (A0) and (A1). This releases (T0), and also causes the (11A') relay to operate.

The second digit of a service code is any digit except "one". The registration of this digit is retained on the A-digit and the walking circuit is advanced so that the third digit will be registered on the B register relays. This difference in operation is a result of the fact that only with the combination of the (A0) and (A1) pair of relays is the "H" lead ground not closed through, and there is no locking path for these two relays when they are operated together.

TX CODES

A TX code is prefixed with "11". In this case the first "one" is registered on the (11A) and (11A') relays as just described. The second "one" operates (A0) and (A1) as before, but (11B) is operated through a front contact of (11A'). Resistance battery is connected through a front contact of (11B) to operate (T0) as before, releasing (A0) and (A1). This causes (11B') to operate. With (11B') operated a front contact closes the "H" lead to the (AA) relay independently of the A-register contacts; a front contact on (11B') also provides an independent path for the locking windings of (A0) and (A1). Therefore the next digit will be registered and locked on the A-register, even if it is a "1", and the walking circuit will be advanced. The second digit following the "11" is registered on the B-register; if three-digit TX codes are used, the third digit is registered on the C register.

No provision is made for the use of combined two and three-digit TX codes. TX codes must all be two-digit, or all three-digit, prefixed by "11".

INDICATION THAT REGISTRATION IS COMPLETED OS - 63, 73

Relay (STC) operates on all calls when registration, including the start pulse, has been completed and the marker has sent a regular release signal to the sender, in order to indicate that certain functions may proceed. If PCI Fig. A is equipped, then in order to operate (STC) either (STA) or (STB') is operated first, the former in case the call is for a manual station with number 10,000 or over, the latter for all other calls.

The path for operating (STA) or (STB') starts from ground through a front contact of (ST), and then through front contact of (DRL). From this point various paths are used, depending on the type of call.

If (XB) is not operated, the operating path for (STA), or (STB') is through a back contact of (XB). If the marker operates (XB), on crossbar or direct call indicator calls (C) and (C') are operated by the front contact of (XB), and the operating path for (STA) or (STB') is through a front contact of (C).

On straightforward class, or 3-digit PCI class, the marker operates (OD) to show that no number is required. The (STB') operating path includes a front contact of (OD), back of (SS5), back of (HL) to (STB') winding.

On panel, crossbar, and 4-digit direct or tandem CI calls, the path is through a front contact of (GL), back of (SS5), back of (HL) to (STB') winding.

A station digit is dialed on a call for a manual office having party line letters, numbers over 9999, or both. The (SD1) relay is operated by the marker except on calls to manual offices having numbers over 9999. When (SD1) is operated, the (STB') operating path is through back of (SS5), front of (GL), (HL) and (SD1) to (STB') winding. If (SD1) is not operated the path is as above to the (SD1) relay, where it passes through a back contact of (SD1) to contacts on the register relays for the thousands, hundreds and tens digits, which determine whether the first three digits of the number are 100 to 104, or not. If the number is not in this range the path is from the back contact of (SD1) through the register relay contacts to the winding of (STB'). If the number registered is "1" on the thousands (D-) register, 0 on the hundreds (E-) register, and 0 to 4 on the tens (F-) register, the path is from the back contact of (SD1) through the register contacts to the (STA') relay winding.

In the preceding paragraph "Z" wiring is assumed. If "Y" wiring is used the contacts of the tens register (FA5) relay are not included in the path for the operation of (STB') or (STA'). With "Y" wiring the (STA') relay is operated only if the thousands digit is 1, and the hundreds digit is 0. Otherwise (STB') is operated.

On SXS and MF classes the path for operating (STB') is through the front contact of (SS5) to the winding of the (STB') relay.

With either pair, (STA), (STA') or (STB), (STB') operated, the (STC) relay operates and locks to off-normal ground.

COMMUNICATION WITH MARKER OS - 66

This section describes how the sender seizes a marker, sends to it the office code and other information, receives back all necessary information for the sender to make its selections, breaks down the direct connection by which the above information was transmitted, and receives a signal by way of the trunk when the marker has established a connection through trunk link and office link frames, so that the sender may proceed with its selections beyond those frames. It also describes how the sender rejects all information received from the marker and seizes a marker for a second or third trial in case the first or second marker encounters any trouble in its functions or the sender later encounters an overflow condition in its selections beyond.

FIRST MARKER TRIAL

Relay (DST) operates through back contact of (OE) when (CL) or (ST) operates. (CL) is in series with the locking ground for the B-register relays when (TD) is operated for two-digit codes, or the C-register relays for three-digit codes, and therefore operates at the completion of office-code registration. The (CL) relay holds the (ON1) relay operated to prevent reseizure of the sender before (CL) has released. (DST) operates from a front contact of (ST) on service codes or two-digit TX codes.

(DST) operated connects battery to leads "ST" and "CBS" to the marker connector, with the effect that the latter connects the sender to an idle marker as soon as the connector and a marker are available.

Office code and other information passes from the sender to the marker over some of these leads as described later, and after decoding, selection information passes from the marker to the sender over other leads.

After decoding and seizing office and trunk link frame connectors, the marker grounds lead "DC" which is one of the leads through the marker connector, and so operates relay (DC). The ground applied by the marker, besides operating relay (DC) operates the (F) relay in the trunk over the "DC" lead running through the sender link and that relay extends the lead through the trunk link frame connector to another point in the marker, where another ground is supplied to it. This second ground holds relay (DC) locked up for a time after the direct connection between sender and marker is broken by the release of the marker connector.

When the marker has sent its selection information to the sender and has also operated relay (DC), it grounds lead "RL" through the marker connector. This operates (DRL) which locks up for as long as (DST) remains operated which is for the duration of the sender usage unless a second trial should be required. (DRL) breaks the "ST" lead, thereby releasing the marker connector and breaking all direct connections between sender and marker.

The sender is still in indirect communication with the marker through the sender link and tandem trunk. When the marker has completed its work of establishing a connection it removes ground from the "DC" lead and relay (DC) releases. This signals the sender to proceed with its work.

If the marker finds all trunks busy, including alternate route trunks, if any, and overflow trunks, it grounds the "RO" lead, operating the "RO" relay in the sender.
The (RO) relays locks, and operates (DRL), releasing the marker connector and marker. It also connects resistance battery to the (FL) interrupter to cause a reorder signal to be sent to the originating end, as described previously.

If the marker encounters trouble in attempting to establish connection to an idle trunk it gives the sender a "trouble-release" signal so that the sender may make a second marker trial.

If the marker encounters trouble in receiving information from the sender, in decoding, or in transmitting information to the sender, it grounds the "TRL" lead to the sender through the marker connector, operating (TRL) on its secondary winding.

If the marker encounters trouble or an all-channels-busy condition during its marker stage, while trying to establish connection to a chosen idle trunk (original, alternate, or overflow), after its direct connection to the sender through the marker connector has been released, it sends a trouble release signal to the sender by grounding lead "D" through the trunk link frame, tandem trunk, and sender link, for a moment only. This operates and releases (TRL) on its primary winding.

When the (TRL) relay is operated through the marker connector it operates (TR1). This releases (DST) which opens the "ST" lead thereby releasing the connector and breaking all direct connections between the sender and the marker. Lead "TRL" being broken with the rest, (TRL) releases and (TR2) operates in series with (TR1). That operates (DST) again with the result that a second connection is made through the marker connector to a marker. This may be the same marker as before but usually will be a different one, since the first marker holds itself busy momentarily after sending a trouble release.

When the trouble release is received through the trunk link and sender link, ground on the "D" lead operates (TRL) through front contact of (DC), which operates (TR1). This releases (DST), which releases (DRL). The release of (DRL), releases all selection register relays and all relays fed by off-normal battery. These relays may therefore be set up in an entirely new pattern on the next marker trial, as may be necessary for an alternate route, for example. When the ground on lead "D" is removed by the marker, (TR2) operates, in series with (TR1), for a second marker trial.

MARKER SEIZURE ON TRUNK TEST FAILURE

When the (TG) relay fails to operate during "TG" test of a trunk set up on a first trial call, a marker is called in to obtain a trouble indicator record of the failure. Having set up the record on the trouble indicator, the marker gives the sender a trouble release signal by grounding the "TRL" lead through the marker connector. The sender then makes a second trial marker call.

When (S5') relay is operated for office test, or (STG') is operated for trunk test a ground is connected from front contact of (FO3) through back contact of (TG6) to the armature of the (TM4) interrupter, to start a 3 to 6 second timing interval for trunk test. If the (TG2) relay operates, as it should, the (TG6) relay is operated, cancelling the timing test. If (TG2) has not operated the first back contact closure of the interrupter operates (TG5), which locks, and three seconds later (TG4) operates and locks. Relay (TG4) grounds the "TGF" lead to indicate to the marker when reseized that it was called in because of a TG failure. (TG4) also starts the release of slow-release relay (TG3). During the interval when (TG4) and (TG3) are both operated, (DST) releases, releasing (DRL). When (TG3) finally releases the (DST) relay is operated, to reseize the marker with the "TGF" lead grounded.

This "TGF" seizure of the marker will be made only on first trial calls, since (TG6) is operated by (TG2) on other trials.

SECOND MARKER TRIAL

A second trial is indicated to the marker by ground on the "TR2" lead from the (TR2) lead in the sender

The second trial may be made because of a trouble-release by the first marker as previously described; or it may result from the operation of the (TRL) or (SOF) relay due to a reverse battery overflow signal received over the trunk connection established on the first marker trial.

On a second trial the marker will set up a connection to the alternate route if provision is made for an alternate route on the office code called. If no alternate route is provided the marker will proceed to set up the call to the same trunk group as on the first trial, but the order of testing the trunks will be reversed, so that usually the trunk chosen will be different from the one used on the first trial.

If the marker finds all trunks busy, including overflow trunks, or if trouble is encountered in the decoder stage, the marker returns a trouble release signal to operate (TRL) by way of the marker connector. If trouble is encountered during the marker stage, (TRL) is operated by way of the trunk link and sender link "D" lead. In either case relays (TR3) and (TR4) are operated in a similar manner to that described for (TR1) and (TR2). The operation of (TR3) and (TR4) results in a third marker trial, calling for connection to an overflow trunk.

Relays (TR3) and (TR4) may also be operated for a third marker trial by the operation of (TRL) or (SOF) due to reverse battery overflow signal received on the trunk connection established on the second trial.

THIRD MARKER TRIAL

When the sender operates (TR3) and (TR4) for a third marker trial the "OF" lead is grounded to indicate to the marker that it is a third trial.

With the "OF" lead grounded the marker will make connection to an overflow trunk.

If the third trial encounters any one of the trouble conditions which cause a retrial the "TRL" lead will be momentarily grounded a third time operating (TRL); (TR1), (TR2), (TR3) and (TR4) all being locked up, (TRL) will operate (RO). (RO) operates, locks and operates (DRL) which holds the relays operated by the marker. (DRL) breaks the "ST" lead releasing the marker connector. (RO) also connects resistance battery to the (FL) interrupter, to send reorder signal to the originating end for a measured interval, or until the originating end disconnects.

In case all overflow trunks are busy the marker grounds the "RO" and and "TRL" leads to the sender. The "RO" lead ground operates relay (RO) for reorder signal to the originating end as just described.

INFORMATION FROM SENDER TO MARKER

The sender transfers to the marker the number of the trunk link frame involved, the class of trunk, the office code, first second or third trial signal and a trunk guard failure signal by grounding a selection of leads "FOO" or "F10"; "CS0" to "CS4", "CS5" or CS6"; "FO" to "F4", "FA5" or "FB5", "BO" to "B4", "BA5" or "BB5", "DO" to "D4", "DA5" or DB5", "GO" to "G5","GA5" or "GB5", "TR1", "TR2", "OF", "TGF"; "MF"; and "EA" or "LA". Lead "MFM" is grounded to enable the marker to distinguish between this sender and other tandem senders which do not have MF outpulsing.

The code used in transmitting frame and code to the marker is as follows; One lead in the set 0 to 4 is always grounded and only one, and one lead in the set A5 or B5, the A5 and B5 standing for above five or below five. The combination then gives the digit required. In addition, in the case of frame indication, one of leads "F00" or "F10" is grounded to indicate a frame below ten or above ten respectively.

Lead "MF" to the marker is grounded to indicate the type of sender, to provide for trunk link peg-count registration by type of sender.

In the case of a two-digit code the (TD) relay grounds leads "D0" and "DB5" as if zero had been registered on the B-register, and also operates relays (TXB) and (TXC). The latter relays transfer the contacts of the B-register from the marker "D" leads to the marker "G" leads, and open the connections from the C-register contacts to the marker "G" leads.

The operation of relays (11A) and (11A') by the initial "one" of a service code grounds leads "B1" and "BB5" to the marker, and operates relays (TXA), (TXB), and (TXC). These relays (a) transfer the contacts of the A-register from the marker "B" leads to the marker "D" leads; (b) transfer the contacts of the B-register from the "D" leads to the "G" leads; and (c) open the connections from the C-register to the "G" leads.

For two-digit TX codes "S" wiring is used at the (11B') relay. The "S" wiring straps on the back contacts of (11B') relay prevent opening the ground connections to the marker "B1" and "BB5" leads from the (11A) and (11A') relays, and permit operation of the (TXA), (TXB) and (TXC) relays with results as described in the preceding paragraph.

Operation of (11B') on TX codes grounds the "EA" lead to the marker, and removes ground from the "LA" lead, which is grounded in all other cases. This enables the marker to distinguish TX codes from other codes.

For three-digit TX codes "T" wiring is used at the (11B) relay. A break contact on (11B) prevents the operation of (TXA), (TXB) and (TXC) relays, so that the contacts of the A, B and C registers are connected to the marker "B", "D" and "G" leads, respectively, in the same way as for regular office codes.

The leads from the A-register contacts to the marker are carried through transfer contacts on the (BTR) relay. This enables the connection of these leads thru back contacts of (BTR) to the "L2" to "L9" cross-connection terminals to operate relay (TD) on two-digit codes. The operation of (DST) operates (BTR) which transfers these leads to the (TXA) relay and thence to the marker.

Relay (AB5) remains operated if the A-digit is 0 to 4, but is released if the A-digit is 5 to 9. A transfer contact on the (AB5) relay is therefore used to ground the "BB5" or "BA5" leads to the marker.

Lead "TR1" is grounded on first trials, "TR2" on second trials and "OF" on third trials. "TGF" is grounded when the marker is called in to record a (TG) failure.

INFORMATION FROM MARKER TO SENDER

The marker transmits selection information to the sender by grounding a selection of leads to operate the corresponding designated selection register relays in the sender. The relays do not lock up until relay (DRL) is operated by the marker, so they may be released and set up in a different pattern if the marker reroutes the call. Even after they are locked up they may be released for a second or third trial by releasing (DST).

The (OB) relays are used to register the office brush selection on a revertive pulse call, or the arbitrary (converted) "A" digit to be outpulsed on a SXS or MF call, as follows:

(OB) Relays	Office Brush Selection	"A" Digit Out.
None	0	1
(OB1)	1	2
(OB2)	2	3
(OB1), (OB2)	3	4
(OB4)	4	5
(OB5)	5	6
(OB5), (OB1)	6	7
(OB5), (OB2)	7	8
(OB5), (OB1), (OB2)	8	9
(OB5), (OB4)	9	0

The marker OB cross-connections are arranged to operate relay (IG5) in the sender when one code digit or two code digits are to be outpulsed by MF or SXS pulses. None of the (OB) relays are operated in this case.

The marker is also arranged to operate both (IG5) and (OB5) to cause the operation of the (TXO) relay when a TX code or a service code is to be outpulsed by SXS or MF pulses.

The (OG) relays are used to register the office group selection on a revertive pulse call, or the arbitrary (converted) "B" digit to be outpulsed on a SXS or MF call, as follows;

(OG) Relays	Office Group Selection	B Digit Out.
None	0	1
(OG1)	1	2
(OG2)	2	3
(OG1), (OG2)	3	4
(OG4)	4	5
(OG5)	5	6
(OG5), (OG1)	6	7
(OG5), (OG2)	7	8
(OG5), (OG1), (OG2)	8	9
(OG5), (OG4)	9	0

The marker cross-connections are arranged to operate the (SO) relay if no office selections are required on a revertive pulse call; or if no code digit or only one code digit is to be outpulsed on a SXS or MF call.

The (CR) relays are used to provide compensating resistance on revertive pulse or call indicator calls, or to register the arbitrary (converted) "C" digit to be outpulsed on a SXS of MF call, as follows:

(CR) Relays	Beyond Office Compensating Resistance, Ohms	C Digit Out.
None	0	1
(CR1)	300	2
(CR2)	600	3
(CR1), (CR2)	900	4
(CR4)	Note 1	5
(CR5)	Note 2	6
(CR5), (CR1)		7
(CR5), (CR2)		8
(CR5), (CR1), (CR2)		9
(CR5), (CR4)		0
(CR2), (CR4)	Note 3	
(TW)	Note 4	

Note 1 - The (CR4) relay provides the compensating resistance for office selections on revertive pulse or call indicator calls. With the (CR4) relay normal 900 ohms compensating resistance is provided. With (CR4) operated no compensating resistance is used in the fundamental circuit for office selections.

Note 2 - (CR5) is operated for trunk groups containing some trunks to non-repeating ground cut-off panel incoming selectors. It serves to substitute relay (MTG) for (TG); to close a cable discharge circuit before final brush selection; and to close an auxiliary path for operating the (O), (BO) and (FO) counting relays through a late-making contact of relay (IA).

Note 3 - The (CR2) and (CR4) relays are operated when code digits are to be out-pulsed as registered. This combination operates the (CCC) relay to cancel code conversion, so that the code digits will be transmitted as registered, - from the C-digit register when one code-digit is required; from the B and C digit registers when two code-digits are required; and from the A, B and C registers when three code-digits are required.

Note 4 - The (TW) relay may be operated with any of the (CR) relays above. It is operated for the following purposes:

(a) on calls routed through distant office selectors or panel sender tandem, to extend the timing period for stuck sender, and to avoid leaving the office selector or tandem sender off normal on abandoned call indicator calls;

(b) on calls through other tandem senders, to extend the timing period for stuck sender;

(c) on calls to ADCI equipment to avoid a position-locked-in condition on abandoned calls.

The class of call is determined by the operation of the following relays:

Relays	Class
None	Revertive Pulse to Panel Office
(XB)	Revertive Pulse to Crossbar Office, Low-Five Incoming Group
(XB), (IG5)	Revertive Pulse to Crossbar Office, High-Five Incoming Group
(SSA), (RBS)	SXS, loop pulsing A, direct to sender
(SSA)	SXS, loop pulsing A
(SSB)	SXS, loop pulsing B
(SSA), (SSB)	SXS, battery-and-ground pulsing
(MFA), (SSA), (RBS)	Multifrequency pulsing
(CI), (TCI)	Tandem Call Indicator, 7 or 8 digits
(CI), (XB), (TCI)	Direct Call Indicator, 4 or 5 digits
(CI), (OD), (TCI)	Tandem Call Indicator, 3-digit code
(OD), (TCI)	Overflow, Vacant Code, Straightforward

The (SD1) relay is also operated on all non-call-indicator classes. On call indicator classes it is operated except to offices having line numbers over 9999.

On step-by-step calls the pulsing provisions are used as follows:

Loop pulsing "A" is used for pulsing into:

1. Local Switch Train
2. AB Toll Train
3. Incoming Repeaters
4. Other two-wire trunk circuits such as SD-95060
5. Senders and Registers

Loop pulsing "B" is used for pulsing into:

1. Four-wire Repeater and Trunk Circuits, such as SD-25490-01 or SD-25634-01

Battery and Ground pulsing is used for pulsing into:

1. Local Switch Train
2. AB Toll Train

GENERAL METHOD OF SELECTION AND SELECTION PROGRESS ON PANEL OR CROSSBAR CALL OS - 67, 68, 69, 70, 71

This section describes how one typical selection is made and how the selection sequence circuit is advanced to make the necessary internal connections for the several selections and office and trunk tests.

TYPICAL SELECTION

Office group selection may be taken as typical. While it is being made, relays (S7) and (S7') are locked up and the other (S) relays and the (FS) relays are normal. The (OG) relays in the selection register are locked up in a pattern appropriate to the office group desired.

When ready to start, the fundamental is closed through the windings of (STP) by the operation of (FO3) and that starts the distant circuit to sending pulses. Each pulse operates and releases (STP) which sends a pulse of ground through back contacts of (FS3), front of (OF2), back of (SS1), to counting relay circuit beginning at the contacts of counting relay (6'). (OF2) is operated early by off-normal ground through back contacts of (OF1) and (MFC).

At the start (RC) is operated and the counting relays normal. Assume (OG1) and (OG2) normal, (OG4) and (OG5) operated, which means that office group 9 is desired, requiring the distant circuit to return ten pulses. The path for the first pulse from (STP) contact is through back contacts of (6'), (1'), (FO5), and (S8), front of (S7) back of (FS2), (OG1), and (OG2), front of (OG4) and back of (MFC) and (4') to the windings of (4') and (4). When the pulse starts (4) operates and when it stops (4') operates in series with (4) and they lock through front contact of (4), back of (6) and front (FO3). The second, third and fourth pulses operate (3)-(3'), (2)-(2') and (1)-(1') similarly and they lock similarly except that (1)-(1') lock through a break-of (SS1) and a make of (FO3).

The path for the fifth pulse is through back contact of (6'), front of (1'), back of (FS2), front of (S7), and (OG5) and back of (MFD) to the winding of (6) and (6'). This pulse operates (6)-(6'), the sixth pulse operates (5)-(5') and these relays lock through a front contact of (FO3) and back of (FO2) respectively.

When (6) operates, (4)-(4'), (3)-(3') and (2)-(2') release and when (5) operates (RC) releases. The seventh, eighth and ninth pulses operate (4)-(4'), (3)-(3') and (2)-(2') a second time and they now lock up through a back contact of (RC). The tenth pulse operates (0), (BO) and (FO) through a back contact of (RC), and they lock to a front of (FO3).

Should (OG1), (OG2) and (OG4) be set up in different pattern, the first pulse would operate (3)-(3') or (2)-(2') or (1)-(1') or (6)-(6') and from one to four pulses less would be required to operate (0), (BO) and (FO). Should (OG5) be normal the pulse which has been described as operating (6)-(6') would operate (O), (BO) and (FO) instead and this result would require five pulses less than when (OG5) is operated.

The operation of (BO) and (FO) is the signal to stop and selection and get ready for the next selection. (BO) breaks the fundamental and thereby stops the advance of the distant circuit. (FO) operates (STG) through a front contact of (S7'). (STG) operates (FO1), (FO1) operates (FO2) and that releases (FO3). (FO2) and (FO3) make additional breaks in the fundamental anticipating the release of (BO), and unlock the counting relays, which release.

The release of (FO) allows (STG') to operate in series with (STG) and they lock up to make the proper connections for trunk test. The operation of (STG') breaks the locking path for (S7)-(S7') and they release. The release of (S7') releases (FO1) unless it is held through a back contact of (DL) relay awaiting registration of the thousands digit on a panel call, or back contact of (EL) relay awaiting hundreds on a crossbar call.

When (FO1) releases, (FO2) also releases operating (RC) to prepare the counting circuit and then (FO3) operates to close the fundamental for trunk test.

PROGRESS OF SELECTION SEQUENCE

On any class of call requiring office selections the sequence relays are operated as follows for the several stages up to and including trunk test:

(S5)-(S5')	Office Test
(S6)-(S6')	Office Brush Selection
(S7)-(S7')	Office Group Selection
(STG)-(STG')	Trunk Test

On a panel or crossbar call the sequence relays are operated as follows for the stages after trunk test:

(S3)-(S3')	- Incoming Brush Selection
(S4)-(S4')	- Incoming Group Selection
(S5)-(S5')	- Final Brush Selection
(S6)-(S6')	- Final Tens Selection
(S7)-(S7')	- Final Units Selection
(STG)-(STG')	- Incoming Advance

On a CI call (STG)-(STG') remain up after trunk test throughout the CI pulsing.

OFFICE SELECTIONS

Office selection consists of three operations, office test, office brush selection, and office group selection. Office test is made with relays (S5) and (S5') operated, office brush with (S6) and (S6'), and office group with (S7) and (S7').

FUNDAMENTAL CIRCUIT

During office test the fundamental is closed from the "FT" lead through back contacts of (MFF), (FTT), (AV2) and (AV), front of (FO3), back of (FO2), (CFO) and (SS2), front of (S5) back of (FS1), the winding of either (TG) or (MTG), back or front contact of (CR5), back of (SS5), (OP2) and (CI2), 14,500 ohms resistance, front contact of (S5'), and the compensating resistance determined by (CR4), back of (AV), (FTT) and (MFF) to the "FR" lead.

During office brush and group selections the fundamental is closed from the "FT" lead through the back contacts of (MFF), (FTT) and (AV2), back of (AV), front of (FO3), back of (FO2) and (CFO), the operating winding of (OF) shunted by its non-inductive winding, front contact of (S6') or (S7') winding of (STP), back contact of (BO), (SS3) and (FS2), front contact of (S6') or (S7') and compensating resistance as above, back of (AV), (FTT) and (MFF) to the "FR" lead.

The purpose of the 14,500 ohm resistance in office test is to prevent the line relay of the tandem trunk or office selector from operating until (STP) is in circuit and the sender is otherwise ready to count pulses.

OFFICE TEST

The fundamental is closed when relays (S5') and (FO3) are operated. (S5') operates for office test upon the release of (DC) when the marker establishes connection to the trunk, (S5) having operated upon operation of (DC) and (DRL). (FO3) operates for office test when (DST) and (RC) operate.

(TG) or (MTG) operates to battery from the distant circuit when that is normal, (TG) operates (TG1) and that in turn operates (TG2) or (MTG) operates (TG2) and that operates (TG1).

(TG2) operates (O), (BO) and (FO) through back contacts of (SSA), (SSB), (SS4) and (STG); and operates (TG6) directly. (FO) operates (S6), which operates (FO1); (FO1) operates (FO2) which releases (FO3) and opens the locking circuit for (TG1). The release of (FO3) breaks the fundamental and the locking circuit for (O), (BO), and (FO). Therefore, all the (TG) and counting relays release.

The release of (FO) allows (S6') to operate in series with (S6) and they lock. (S6') opens the locking circuit for (S5)-(S5') and they release. (S5') releases (FO1) which releases (FO2) and then (RC) and (FO3) operate for office brush selection.

OFFICE BRUSH SELECTION

Office brush selection follows immediately after office test, starting when (FO3) operates to close the fundamental.

(STP) responds to pulses from the distant circuit, (OF) not operating because of its polarity (STP) sends from 1 to 5 pulses with (OB5) normal or 6 to 10 pulses with (OB5) operated to the counting relays through the front contact of (S6), back of (TXO) and (FS2) and the contacts of the (OB) relays. (O), (BO) and (FO) operate on the last pulse and lock.

(BO) breaks the fundamental and (FO) operates (S7) through a front contact of (S6'). (S7) operates (FO1) which operates (FO2) and that releases (FO3). (FO2) and (FO3) make additional breaks in the fundamental anticipating the release of (BO), and unlock the counters, which release.

The release of (FO) allows (S7') to operate in series with (S7) and they lock. (S7') opens the locking circuit for (S6)-(S6') and they release. (S6') releasing releases (FO1), which releases (FO2) and then (RC) and (FO3) operate for office group selection.

(OB5) is provided for use to a crossbar R.P. tandem office to increase the number of codes.

OFFICE GROUP SELECTION

Office group selection follows immediately after office brush, starting when (FO3) operates to close the fundamental.

(STP) sends from 1 to 10 pulses to the counters as described previously in detail, eventually operating (O), (BO), and (FO).

(BO) breaks the fundamental and (FO) operates (STG). (STG) operates (FO1) which operates (FO2) and that releases (FO3). (FO2) and (FO3) make additional breaks in the fundamental and unlock the counters.

The release of (FO) allows (STG') to operate in series with (STG) and they lock. (STG') opens the locking circuit for (S7)-(S7') and they release. (S7') releases (FO1) which releases (FO2) and then (RC) and (FO3) operate for trunk test.

SKIP OFFICE

If there is to be no office selection (SO) is operated by the marker. Then the operation and release of (DC) operates (STG) and (STG') for trunk test instead of operating (S5)-(S5') for office test. The locking circuit for these (S) relays is provided by (DRL) so they will not remain locked up in case the marker in shifting from one trunk group to another first operates (SO) and then releases it.

REVERTIVE PULSE CALL TO PANEL OR CROSSBAR

This section describes all the operations on a call to panel or crossbar which are peculiar to that class. Panel is distinguished by no class relays being operated and crossbar by the (XB) relay being operated. (XB) serves to delay trunk test until the hundreds digit has been dialed, instead of after the thousands digit as on a panel call, and also to eliminate the use of (FO1) which serves to provide more time between selections. With these exceptions the two classes are treated exactly the same.

FUNDAMENTAL CIRCUIT

During trunk test the fundamental is closed from the "FT" lead through back contacts of (MFF), (FTT), (AV2) and (AV); front of (FO3), back of (FO2), (CFO) and (SS2), front of (STG), back of (TCI), back of (FS1), the winding of either (TG) or (MTG), back or front contact of (CR5), back of (SS5), (OP2) and (CI2), 14,500 ohms resistance, back of (TCI), front of (STG'), compensating resistance as determined by transfer contacts of (CR1) and (CR2), back of (AV), (FTT) and (MFF) to the "FR" lead.

During incoming and final selections and incoming advance the fundamental is closed from the "FT" lead through back contacts of (MFF), (FTT) and (AV2), back of (AV), front of (FO3), back of (FO2) and (CFO), the operating winding of (OF) shunted by its non-inductive winding, front contact of (FS1), back of (SS3), winding of (STP), back contact of (BO) another back of (SS3), front of (FS2) and compensating resistance as above, back of (AV), (FTT) and (MFF) to the "FR" lead.

The purpose of the 14,500 ohms resistance in trunk test is to prevent the line relay of the panel incoming selector or the crossbar incoming trunk from operating until (STP) is in circuit and the sender is otherwise ready to count pulses.

If relay (CR5) is operated, then just before the fundamental is closed through the (STP) for final brush selection, it is momentarily closed through 25,500 ohms and the compensating resistance by back contacts of (FO3), (SS3) and (S6) and front of (S5) and (CR5), in order to discharge the trunk cable and avoid danger of a false pulse through (STP).

TRUNK TEST

The fundamental is closed when relays (STG') and (FO3) are operated. (STG') operates upon the release of (DC) when the marker establishes connection to a trunk if the call is skip office, (STG) having operated upon operation of (DC) and (DRL); or upon the completion of distant office selections. (FO3) operates upon release of (FO1) and (FO2) following the operation of (DL) on calls to panel or (EL) on calls to crossbar offices, and the completion of distant office selections, if any, releases (S7').

If the trunk is in a group containing non-repeating ground cutoff incomings (MTG) is cut into the fundamental. Otherwise (TG) is used instead. Whichever relay is used operates to battery and ground from the distant end of the trunk when that is normal.

The operation of (TG) operates (TG1) and that in turn operates (TG2), or the operation of (MTG) operates (TG2) and that in turn operates (TG1). (TG2) operates (O), (BO) and (FO) through front contact of (STG) and back of (TCI) and operates (TG6) directly. (FO) operates (S3) which operates (FO2). This releases (FO3) and opens the locking circuit for (TG1). The release of (FO3) breaks the fundamental, and the locking circuit for (O), (BO), and (FO).

The release of (FO) allows (S3') to operate in series with (S3) and they lock. (S3') opens the locking circuit for (STG)-(STG') and they release. (STG') releasing releases (FO2) and then (FO3) and (RC) operate for incoming brush selection.

The operation of (S3') also operates (FS1) and (FS2) in parallel and they lock up and make proper connections for incoming and final selections.

INCOMING BRUSH SELECTION

Incoming brush selection is made with relays (S3) and (S3') operated. It follows trunk test without delay for digit registration, starting when (FO3) closes the fundamental.

(STP) responds to pulses from the distant end of the trunk (OF) not operating because of its polarity, and (STP) sends from 1 to 5 pulses through the contacts of (S3) and the (D-) register relays to the counting relays. (O), (BO) and (FO) operate on the last pulse and lock up.

(BO) breaks the fundamental and (FO) operates (S4) through a front contact of (S3'). (S4) operates (FO1) which operates (FO2) which releases (FO3) on panel, or (S4) operates (FO2) on crossbar. (FO2) and (FO3) make additional breaks in the fundamental, anticipating the release of (BO), and unlock the counters.

The release of (FO) allows (S4') to operate in series with (S4) and they lock. (S4') opens the locking circuit for (S3)-(S3') and they release. (S3') releases (FO1) unless it is held for hundreds registration on a panel call and then (RC) and (FO3) operate for incoming group selection.

INCOMING GROUP SELECTION

Incoming group selection is made with relays (S4) and (S4') operated, starting when (FO3) operates to closethe fundamental, after the completion of incoming brush selection and the registration of hundreds, and functions the same as incoming brush except in the following particulars.

(STP) sends from 1 to 4 or 6 to 9 pulses through the contacts of relay (S4) and the (D) and (E) register relays to the counting relays eventually operating (O), (BO) and (FO).

(FO) operates (S5) through a front contact of (S4'). (S5) operates (FO1) which operates (FO2) if the call is to panel with (XB) normal or (S5) operates (FO2) directly if (XB) is operated. (FO2) releases (FO3) which releases the counters.

The release of (FO) allows (S5') to operate in series with (S5) and they lock. (S5') opens the locking circuit for (S4)-(S4') and they release. (S4') releases (FO1) which releases (FO2) or releases (FO2) directly and then (RC) and (FO3) operate for final brush selection. There is no delay for digit registration at this point.

Incoming group selection consists of sending 1 to 4 pulses. To provide for distinguishing between two terminating units using trunks in common, five additional pulses may be sent if (IG5) is operated.

FINAL BRUSH SELECTION

Final brush selection is made with relays (S5) and (S5') operated, starting when (FO3) operates to close the fundamental after incoming group selection, and functioning the same as incoming brush selection except in the following particulars.

(STP) sends from 1 to 5 pulses through the contacts of relays (S5) and the (E) register relays to the counting relays eventually operating (O), (BO) and (FO).

(FO) operates (S6) through a front contact of (S5'). (S6) operates (FO2) and that releases (FO3) on crossbar class, or (FO1) operates (FO2) on panel class, and the counters release.

The release of (FO) allows (S6') to operate in series with (S6) and they lock. (S6') opens the locking circuit of (S5)-(S5') and they release. (S5') releases (FO1) and (FO2) unless they are held for tens registration, and then (RC) and (FO3) operate for final tens selection. (FO2) will not release nor (FO3) operate until the registration of the tens digit operates (FL).

FINAL TENS SELECTION

Final tens selection is made with (S6) and (S6') operated, starting when (FO3) operates to close the fundamental after the completion of final brush selection and the registration of tens, and functions the same as incoming brush except in the following particulars. Relay (FS3) operates with (S6) and locks up to switch the contacts of (STP) during the succeeding selections in order to minimize wear on them.

(STP) sends from 1 to 10 pulses through the contacts of relay (S6) and the (F) register relays to the counting relays eventually operating (O), (BO) and (FO).

(FO) operates (S7) through a front contact of (S6'). (S7) operates (FO1) which operates (FO2), or (S7) operates (FO2) directly, and (FO2) releases (FO3) which releases the counters.

The release of (FO) allows (S7') to operate in series with (S7) and they lock. (S7') opens the locking circuit for (S6)-(S6') and they release. (S6') releases(FO1) and (FO2) in turn or (FO2) directly unless they are held for registration, and (FO2) releasing operates (RC) and (FO3) for final units selection. (FO1) and (FO2) will not release until the registration of the units digit and start pulse operates (STC).

FINAL UNITS SELECTION

Final units selection is made with relays (S7) and (S7') operated starting when (FO3) operates to close the fundamental after completion of final tens selection and the registration of the start pulse, and functions the same as incoming brush except in the following particulars.

(STP) sends from 1 to 10 pulses through contacts of relay (S7) and the (G) register relays to the counting relays eventually operating (O), (BO) and (FO).

(FO) operates (FTG) through front contacts of (S7') and back of (CFO); (STG) operates (FO1) which operates (FO2), or operates (FO2) directly. (FO2) releases (FO3) which releases (FO3) which releases the counters.

The release of (FO) allows (STG') to operate in series with (STG) and they lock. (STG') opens the locking circuit for (S7)-(S7') and they release. (FO1) and (FO2) or (FO2) alone now releases, and (FO2) released operates (RC) and (FO3) for incoming advance. Registration having been completed there is no delay at this point.

INCOMING ADVANCE AND TRUNK CLOSURE

Incoming advance is made with relays (STG) and (STG') operated, starting when (FO3) operates to close the fundamental after final units selection.

(STP) and (OF) both respond to a single pulse of reversed battery from the distant end of the outgoing trunk, (STP) operating and releasing, (OF) operating and locking and operating (IA).

When (STP) and (IA) are both operated, (O) operates and when (STP) releases (BO) and (FO) operate and lock in series with (O).

Some non-repeating, ground cutoff, panel incomings give so short a reversed battery pulse that (STP) may not stay operated long enough after (IA) operates to effect the operation of (O), so the above described method of operating (BO) and (FO) at the end of the pulse may fail. To insure the operation of (BO) and (FO), (IA) closes a supplementary path through a front contact of (CR5) to operate (O), (BO) and (FO) simultaneously when (STP) releases in case (O) was not operated before.

The supplementary path would cause (BO) and (FO) to operate too soon in case (IA) should close it before (STP) operates. This is a possibility on long trunks which causes (STP) to lag in operation behind (OF), so to prevent it , the supplementary path is carried through the above mentioned front contact of (CR5) which makes it effective only on trunks requiring it.

When the incoming has cut off the reversed battery it connects direct battery instead on the fundamental and awaits a trunk closure bridge before ringing the called station. The operation of (BO) breaks the bridge across the fundamental in the sender to prevent premature trunk closure.

The operation of (FO) operates (AV) through a front contact of (IA) and back contacts of (OF1) and (SS1). (AV) locks and operates (AV1). (AV1) operated marks the completion of the sender's functions on the call by starting the series of operations described later to release the sender. (AV1) also unlocks (OF).

To remove the residual effect on the (STP) relay of the reverse current received on incoming advance, a current is applied through the (STP) windings in the normal operating direction at the beginning of each call. This current is applied through front contacts of the (DC) relay, which is operated and released on each marker seizure.

CALL INDICATOR CALL 0S-72, 73, 74, 74-1, 74-2, 74-3

This section describes the operations on a CI call which are peculiar to that class. There are three CI classes all distinguished by relays (CI) and (TCI) being operated. In addition (OD) or (XB) may also be operated by the marker. (XB) is operated where numbers only are sent on direct

CI class and (OD) where the code only is received on calls to operators not requiring a number. (OD) serves to cancel trunk test delay waiting for the registration of a number and has no effect after the completion of registration, an operator tandem call being handled exactly like a regular tandem call with number under 10,000, a full set of CI pulses being sent for all digits not registered. (XB) serves to cancel the sending of the office code. The method of sending CI pulses differs according to whether the called number is under or over 10,000.

FUNDAMENTAL CIRCUIT

During trunk test the fundamental is closed from the "FT" lead through back contacts of (MFF), (FTT), (AV2) and (AV) front of (FO3), back of (FO2) and(CFO), the operating winding of (OF) not shunted by its non-inductive winding, back contact of (FS1), the winding of (TG), back contact of (CR5), (SS5), (OP2) and (CI2), front of (TCI), and (STG'); compensating resistance as determined by the transfer contacts of (CR1) and (CR2); back of (AV), (FTT) and (MFF) to the "FR" lead.

While awaiting assignment after trunk test, all (TG) and (CI) relays being operated, the fundamental is closed from the "FT" lead through the back contacts of (MFF), (FTT), (AV2), and (AV), front of (FO3), back of (FO2), (CFO) and (SS2), front of (STG) and (CI2), back of (FS1), winding of (TG), back of (CR5), (SS5) and (OP2), front of (TG2) and (CI1), and compensating resistance as above, back of (AV), (FTT) and (MFF), to the "FR" lead. The operating winding of (OF) is short circuited during this time so that it can not respond to a momentary surge which may occur due to the trunk being disconnected from its previous connection after it has been seized for this connection.

When the trunk is assigned and the (TG) relays released but the (CI) relays still operated, the fundamental is closed from the "FT" lead through back contacts of (MFF), (FTT), (AV2) and (AV), front of (CI1) and back of (TG2) to the CI pulsing circuit and back through another back contact (TG2), front of (CI1), compensating resistance as above, back of (AV), (FTT) and (MFF) to the "FR" lead.

TRUNK TEST

Trunk test and all following operations are made with relays (STG) and (STG') operated. The fundamental is closed when relays (STG') and (FO3) are operated. (STG') operates upon release of (DC) when the marker established connection to a trunk if the call is skip office, (STG) having operated upon the operation of (DC) or upon the completion of office selections. (FO3) operates upon release of (FO2) and operation of (RC) which occur when the completion of registration operates (STG), and the completion of office selections, if any, releases (S7').

(TG) operates to battery and ground from the distant end of the trunk but (OF) does not operate because of its polarity. (TG) operates (TG1) and that operates (TG2). (TG2) operates (CI1) through front contacts of (STG) and (TCI), break of (OFl) and make of (CI); and operates (TG6) directly. (CIl) locks until (AVl) operates after PCI pulses have been sent, and operates (CI2). The (TG) relays hold operated until the trunk is assigned at the distant end, when they release to start the CI pulsing.

GENERATION OF CI PULSES

The CI pulsing circuit consists of start pulse relay (SP), pulse generating relays (PG), (PGl), (PG2) and (PG3), grounding relay (GR), pulse tip and ring relays (PT) and (PR), relays (12) and (34) which supplement the contacts of the register relays, and final pulse relay (FP).

(PG) is a non-biased condenser-timed polarized relay. It closes its front contact when energized in one direction by its primary winding, closes its back contact when energized in the other direction by its primary winding, and remains on either contact or between the contacts when not energized. When current is first closed through the primary in either direction, its force is more than neutralized by an opposing current in the secondary winding, the source of which is the charge or discharge of the timing condenser. When the condenser has been charged or discharged, current ceases to flow in the secondary and the primary causes the armature to move over from one contact to the other. The actual time of operation varies somewhat with variations in voltage, resistance and relay adjustment. It averages about .068 second per operation. Jack (PG) affords a means to patch the windings of relay (PG) separately to a relay test set.

When (PG) closes its front contact, (CIl) and (SP) being operated, it grounds out the 300-ohm battery and so starts opposing currents in the two windings. At first the effect of the secondary winding is stronger and the front contact is held closed, but as the condenser discharges the current in the secondary dies down until the primary winding becomes the stronger when the relay breaks its front contact and closes its back contact. Now the battery through 300 ohms is not grounded out and currents in the two windings are reversed. As the condenser charges the primary becomes effective, so that the relay breaks its back and closes its front contact. Then the cycle repeats.

In sending out CI pulses after the trunk has been assigned and (TG2) released, (PG) pulses as just described with (PGl) operating every time (PG) closes its back contact. The pulsing must start with the timing condenser discharged and the (PG) relays in a definite condition, with (PG) closing its back contact, (PGl) and (PG2) operated and (PG3) normal. The condenser is discharged and (PG) set on its back contact immediately after communication with a marker when (CI) operating with (SP) normal grounds out the 300 ohms resistance. When trunk test is made and (CIl) operates that operates (PGl) and (PGl) operates (PG2), but (PG3) cannot operate because its winding is short-circuited.

When the trunk is assigned and (TG2) released, - and it is not permitted to release until (PG2) and (CI2) have operated, - (SP) operates and then (PG) and (PG1) start continuous pulsing. (PG2) being operated and locked and (PG3) normal before the pulsing begins, the first release of (PG1) removes the short circuit from (PG3) and that operates. The next operation of (PG1) short circuits (PG2) and that releases, leaving (PG3) still up. The next release of (PG1) releases (PG3). The following operation of (PG1) operates (PG2) and so the cycle repeats. Each complete cycle, which generates four pulses to transmit one digit, proceeds as follows:

Pulse	(PG1)	(PG2)	(PG3)
1	Up	Up	Down
2	Down	Up	Up
3	Up	Down	Up
4	Down	Down	Down

When operated (PG1) grounds the "FR" lead for a positive or blank odd pulse, and when normal it grounds the "FT" lead for a negative even pulse. (GR) operates with (PG1) but slightly later.

The winding of (PT) is connected to the digit register so as to be ready in the operated position when a positive odd pulse is required or normal when a blank odd pulse is required. Operated it connects 6500-ohm battery to the "FT" lead, giving the light positive pulse. Normal it connects ground through back contact of (GR) to the "FT" lead, so that both sides of the trunk are grounded momentarily to discharge the trunk capacity, until (GR) operates immediately after (PG1), after which the "FT" lead is open to give the blank pulse. For the first pulse of all (PG1) is operated in advance but (GR) does not operate until (SP) operates to start the pulsing.

The winding of (PR) is connected to the digit register relay so as to be ready in the operated position when a heavy negative even pulse is required, or normal when a light negative even pulse is required. Operated it connects 115-ohm battery to the "FR" lead, giving the heavy negative pulse. Normal it leaves only 6500-ohm battery connected to the "FR" lead, giving the light negative pulse.

After the entire number has been transmitted, relay (FP) is operated if its winding is connected. It breaks the operating circuit of (PG1) when (PG3) is also operated, reverses the "FT" and "FR" leads, and makes such connections as to send out a blank pulse and then a heavy positive pulse, as will be described in detail later.

CONNECTION OF PULSING CIRCUIT TO DIGIT REGISTERS

On the first and fourth pulses of each digit the winding of (PT) is connected through a back contact of (PG3) to certain contacts on the register relays, and on the second and third pulses through a front contact of (PG3) to other contacts on the register relays. These points are grounded or not according to the digit registered and the progress of the operations through the digits. As the operation or non-operation of (PT) is significant only in the first and third pulses, it has in every case the whole preceding pulse to get ready.

Similarly the winding of (PR) is connected on the first and second pulses through a front contact of (PG2) to certain register relay contacts, and on the third and fourth pulses through a back contact on (PG2) to other contacts.

To reduce the number of contacts required on the register relays, (1-2) and (3-4) are furnished, with their windings connected to register relay contacts, and their contacts connected through the front and back contacts of (PG2) and (PG3) to the windings of (PT) and (PR). Then if a certain digit requires (PT) operated for the first pulse and (PR) for the second, (1-2) operates from a register relay contact and in turn operates (PT) and (PR) for the periods during which they should be operated. (3-4) performs a similar function for digits which require (PT) operated for the third pulse and (PR) for the fourth.

The pulses are transmitted in a continuous stream, four pulses to each digit. The first and third pulses of each digit are either blank or light positive, the second and fourth either light or heavy negative. The different combinations of four pulses determine the numeral transmitted for each digit. In addition each negative pulse, whether light or heavy, serves to advance the distant control circuit which receives the pulses and registers the numbers transmitted.

Three different codes of pulse combinations are used, the regular one for office code and all numericals except thousands, the thousands code, and the stations code. These codes are given in the following table, where n represents a light negative pulse, N heavy negative, p light positive and - a blank pulse. The four letters J, M, R, and W corresponding to numerals 5, 6, 7 and 9 are the only stations designations provided for. If no station is registered or if any other numeral is registered in error a zero will be transmitted. The stations code for 1 is not used in sending a stations digit, but is used in sending the first digit of a 10,000 number which is not taken from the station register.

Regular	Thousands	Stations
0 - n - n	0 - n - n	0 - n - n
1 p n - n	1 - n - N	1 p n - n
2 - N - n	2 p n - n	
3 p N - n	3 p n - N	
4 - n p n	4 - N - n	
5 - n - N	5 - N - N	5(J)-n p n
6 p n - N	6 p N - n	6(M)-n - N
7 - N - N	7 p N - N	7(R)pN - n
8 p N - N	8 - n p n	
9 - n p N	9 - n p N	9(W)-N - n

TANDEM CALL, NUMBER UNDER 10,000

When a call is routed through tandem and the called number is under 10,000 relays (STB) and (STB') will have operated in advance as previously described and all the other PCI progress relays (A), (A') to (U), (U') will be normal when the trunk is assigned and pulsing starts.

When the trunk is assigned (TG) releases followed by (TG1) and (TG2). The condenser-resistance bridge about the winding of (TG) absorbs its discharge to prevent a false pulse going out. The purpose of the slow release (TG1) is to prevent false assignment in case (TG) is momentarily released as may happen if the trunk is still connected to a subscriber from the previous connection, and he should hang up while the sender is awaiting assignment. (TG1) and (TG2) are not permitted to release until (CI2) and (PG2) have both operated, to be sure that the pulsing circuit is ready to send pulses.

The release of (TG2) connects the pulsing circuit to the "FT" and "FR" leads through front contacts of (CI1) and operates (SP) to start the pulsing. The contacts of the (A) register are already grounded through back contacts of relays (A) and (A'), so some connections are already set up from ground to the contacts of (PG2) and (PG3) to operate (PR) and (PT) as required for the four pulses of the (A) digit.

The release of (PG2) at the end of the second pulse operates relay (A), which transfers the ground operating (PT) and (PR) on the first and second pulses of a digit from the (A) register to the (B) register. The next operation of (PG2), at the end of the fourth pulse, allows relay (A') to operate in series with (A), and the pair lock in parallel with the winding of (STC). (A') operating transfers the ground for (PT) and (PR) on the third and fourth pulses of a digit from the (A) register to the (B) register.

So the pulsing proceeds, transferring the grounds for operating (PT) and (PR) two pulses at a time through the (A), (B), (C), (H), (D), (E), (F), and (G) registers in turn, by operating the progress relays (A), (A'), (B'),(C), (C'), (STA), (STA'), (TH), (TH'), (H), (H'), (T), (T'), (U) and (U'). Each pair of progress relays locks up either to the pair operating it or to off-normal ground.

(U') operates at the end of the fourth pulse at the units digit, which is the last digit, (STB') being already operated. (U') operates (FP) if its winding is connected, otherwise (AV).

If (FP) is connected, a blank pulse is sent after the fourth pulse of the units digit with (PG) on its back contact, (PG1), (PG2) and (FP) operated and (PG3) normal. Then (PG) breaks its back contact, releasing (PG1) which lets (PG3) operate. (FP) operated reverses the connections between the "FT" and "FR" leads and the contacts of (PG1), and also connects the 115-ohm battery to the "FT" lead, so the release of (PG1) starts a heavy positive pulse.

After the heavy positive pulse has lasted for the usual time of a pulse, (PG) closes its back contact. Usually that would operate (PG1) terminating the pulse and releasing (PG2); but this time, since (FP) and (PG3) are both operated, the back contact of (PG) is cut off from the winding of (PG1) and connected instead to release (PG2) directly. (AV) operates upon the release of (PG2).

The operation of (AV) and (AV1) either after the final pulse or after the units digit, if no final pulse is provided for, marks the completion of the sender's functions on the call. Besides starting the series of operations to release the sender, it also immediately releases the (CI1) and (CI2) relays which stop the pulsing. (AV) also disconnects the "FT" and "FR" leads from the pulsing circuit to terminate the heavy positive pulse.

TANDEM CALL, NUMBER 10,000 OR OVER

When a call is routed through tandem and the called number is 10,000 or over, relays (STA) and (STA') will have been operated in advance and all the other (CI) progress relays are normal when pulsing starts.

The pulsing starts and finishes just as described in the preceding subsection and is the same throughout except that the digit registered on the (H) register is sent last, after that on the (G) register, instead of being sent between those on the (C) and (D) registers because (STA)-(STA') are operated in advance instead of in their regular order and (STB)-(STB') in their regular order instead of in advance.

With (STA) and (STA') operated the pulsing code sent from the stations register is received on the units register, and must therefore follow the regular numerical code, instead of the stations letter code. A different set of contacts is therefore used on the stations (H) register relays.

The code for the digit on the thousands register is received on the stations register, so it must be in the stations code. Since the digit is always 1 for a number over 10,000 it is only necessary to provide two paths for the digit 1 on the (D) thousands register, - i.e., with (D0A) and (D1A) operated, - one path through a front contact and the other path through a back contact of (STB).

DIRECT CI CALL

When a call is routed direct the process of sending pulses is the same as for a tandem call except that the (A), (B) and (C) digits are not sent and the pulsing starts with the stations or thousands digit, depending upon whether the number is under or over 10,000.

Relays (C)-(C') are operated in advance and both the progress relay operating leads and the leads to the register relays are advanced to the stations or thousands relays and registers.

TWO-DIGIT OFFICE CODES

If tandem CI operation is used in an area having any two-digit codes, zero will be sent for the B digit, and the digit registered on the B register will be sent as the C digit, that is, a two-digit code AB will be transmitted as A0B. This is the result of transferring the leads of the B register from back to front contacts of (B)-(B') relays, by the operation of (TD2).

STRAIGHTFORWARD CALLS OS-74-3

This section describes the operations on a completed straightforward call which are peculiar to that class of call. This class is distinguished by (OD) and (TCI) being operated. On these calls (OD) permits the call to be completed after 3 digits have been registered.

There are two classes of calls that may be completed on a straightforward basis. One class, which is the "straightforward direct" class, is completed without office selections and the other, which is the "straightforward through R.P. tandem" class, is completed through a second crossbar tandem sender and requires office selections. These classes are identified in the sender by the operation of the (TW) and (SO) relays. For the direct straightforward class (SO) will be operated and (TW) released; for the second tandem class (TW) will be operated and (SO) released.

STRAIGHTFORWARD-DIRECT CLASS

In order to avoid having the order tone returned before the sender has completed its functions, trunk test is not made on the straightforward trunk. This test, however, is simulated in the sender in order to cause its advance.

Following operation of (DRL), (FTT) operates from front of (DRL), back of (CI), front of (TCI) and back of (TW) to the winding of (FTT). (FTT) operated disconnects (TG) and (OF) from the "FT" and "FR" leads and connects them to battery and ground to simulate trunk test. This circuit is as follows: battery through (W) resistance, front of (FTT), back of (AV2), and (AV), front of (FO3), back of (FO2) and (CFO), operating winding of (OF) not shunted by its non-inductive winding, back contact of (FS1), winding of (TG), back contacts of (CR5), (SS5), (OF2) and (CI2), front of (TCI) and (STG'), back of (CR1), (CR2) and (AV) to ground at front of (FTT). Trunk test does not proceed until the (ST) relay is operated to cause the operation of (STC), which is necessary to release (FO2) and operate (FO3).

When this circuit is closed (TG) operates followed by (TG1) and (TG2). (TG2) operates (AV) and (AV1) followed by sender release in the usual manner. The usual check for open trunk is cancelled by a back contact of (FTT).

STRAIGHTFORWARD THRU REVERTIVE PULSE TANDEM CLASS

For this class (TW) will be operated as well as (OD) and (TCI). Following operation of (DRL) (OP1) will operate from ground through front of (DRL), back of (CI), front of (TCI) and (TW), back of(OP2) and (OP) thence through winding of (OP1) to battery. Following release of (DC), office test will be made in the usual manner as described for a full selector call, followed by office brush and group selections. Trunk test will then be made when the fundamental is closed from the "FT" lead, back of (MFF), (FTT), (AV2) and (AV), front of (FO3), back of (FO2) and (CFD), operating winding of (OF) not shunted by its non-inductive winding, back of (FS1), winding of (TG), back of (CR5), (SS5), (OP2) and CI2), front of (TCI) and (STG') back of (CR1), (CR2), (FTT) and (MFF) to the "FR" lead.

(TG) operates in this circuit followed by (TG1) and (TG2). With (TCI) and (OP1) operated (TG2) operates (OP) and locks. (OP) operated releases slow release (OP1). When (OP1) releases, with (OP) locked a circuit is closed to operate and lock (OP2). (OP2) operated opens the locking circuit for (TG2) and also opens the fundamental which allows the distant tandem R.P. sender to advance awaiting trunk closure. With the fundamental open (TG), (TG1), (TG2) and (OP) release. When (OP) releases, with (OP2) locked, a circuit is closed to operate (AV) and (AV1) followed by trunk closure and subsequent release of the sender.

MF AND SXS OUTPULSING - GENERAL OS 75, 75-1, 75-2

By means of the proper class relays, (SSA), (SSB), and (RBS), operated from the marker, this sender will transmit direct dial pulses (loop pulsing A), compensated loop dial pulses (loop pulsing B), or battery and ground pulses, to terminating dial pulse selectors or senders. The (SS) relay is operated, in turn operating the (SS1) to (SS6) relays. Following trunk test the fundamental circuit is connected to the dial pulse generating circuit, and from one to eight digits may be transmitted to the terminating equipment. The sender then cuts the tandem trunk through to the outgoing trunk, and restores to normal.

For multi-frequency outpulsing the marker operates (MFA), (SSA), and (RBS), which operate all the (SS-) relays and also the (MFA), (MFB), (MFC), (MFD), (MFE) and (MFF) relays. The fundamental circuit is connected in series with the secondary winding of an output repeating coil to the (TG) and (OF) relays for trunk test; the primary winding of the repeating coil is connected to the multi-frequency pulse control relays. From one to eight digits (preceded by "KP" pulse and followed by a "start" pulse) may be transmitted to the terminating equipment. The sender then cuts the tandem trunk through to the terminating equipment, and releases.

NUMBER OF DIGITS TRANSMITTED

This sender may transmit from one to eight digits by dial pulses or multi-frequency pulses, as follows.

One to five numerical digits, as registered on the (D), (E), (F), (G), and (H) registers, sending as many digits as are registered.

One, two, or three code digits, as registered, respectively, on the C digit register, the B and C registers, or the A, B, and C registers; or these code digits may be converted to any other values 0 to 9 by translation by the marker. For code conversion the digits corresponding to the A, B and C digits are registered by the marker on the OB, OG, and CR registers, respectively. When the code digit or digits are to be transmitted as originally registered the marker operates the cancel-code-conversion relay (CCC). The transmission of the code digits will be followed by transmission of whatever numerical digits, if any, have been registered.

Two-digit codes will be retransmitted as two-digit codes, even though registered as three-digit codes by distant operators who are instructed to insert a third code digit on calls which are listed in the local subscriber directories as two-digit codes.

When codes are retransmitted as registered, one route relay in the marker may serve for a large number of office codes handled through a second tandem switching point. However, if the code digits are converted to arbitrary digits, each such arbitrary code requires its own route relay in the marker.

By code conversion, one, two or three digits of any value may be transmitted for any office code, TX code or service code, except that only one or two digits may be transmitted for office codes for which the initial digit registered is a two-digit index.

TX codes, either two-digit (11XX) or three-digit (11XXX) may be retransmitted as registered, including the initial "11". In this case the marker operates the (TXO) relay. The initial digits (11) one sent from the OG and CR registers, and the remaining digits from the code registers.

Service codes 1XX may be retransmitted as registered. The marker operates the TXO relay in this case, in order to send the initial 1 from the CR register.

One or two digits of a two-digit TX code, or one, two, or three digits of a three-digit TX code may be sent out by dial pulses only (not MF). These digits may be transmitted as registered or converted to any arbitrary digits 0 to 9.

INITIAL DIGIT TO BE SENT

The initial digit to be sent may be the first, second, or third code digit, or the first numerical (thousands) digit. This is determined by the operation of the (SO) and (IG5) relays by the marker as follows:

No. of Code Digits to be Sent	Relay Operated by Marker	Start Pulsing from Register	Initial Steering Relays Operated
None	SO -	D	S4, S4'
C	SO, 1G5	C(or CR)	S3, S3'
BC	- 1G5	B(or OG)	S2, S2'
ABC	- -	A(or OB)	S1, S1'

To transmit the initial "11" of a TX code the digit 1 is set up by the marker on the OG and CR registers, and the (TXO) relay is operated by cross-connecting the marker route relay to operate the (OB5) and (IG5) relays. With (IG5) operated the pulsing starts with the (OG) register to send the first 1, and then proceeds to the (CR), A, B, and (for three-digit TX codes) C registers.

To transmit the initial "1" of a toll service code, 1XX, the digit 1 is set up by the marker on the CR register, and the (TXO) relay is operated by cross-connecting the marker-route relay to operate the (OB5) and (IG5) relays. The (SO) relay is also operated by proper (OG) cross-connection of the route relay, so that the pulsing starts at the (CR) register. The second and third digits are then transmitted as registered.

TRUNK TEST

A low resistance trunk test is made, with the (TG) relay shunted by the (TGS) resistance, and the (OF) relay shunted by the (OFS) resistance and its own non-inductive tertiary winding.

A delay of about .750 second is introduced after the outgoing trunk is seized by the marker, before applying the low-resistance trunk test. This interval permits the complete restoral to normal of any terminating equipment which may have been seized immediately following its release from a previous call.

The operation of (DRL) relay for marker release operates (TTD) through a front contact of (DC). This operates (TTE) through a front contact of (SS3), which in turn operates (STG). When the marker has completed the cross-point closure through the trunk link and office link frames to complete the connection of the trunk fundamental tip and ring leads to the sender, the marker signals this condition by releasing the (DC) relay in the sender. This releases (TTD), which releases (TTE), which permits (STG') to operate in series with (STG). The operation of (STG') will close the fundamental circuit for TG test unless it is held open at contacts of the (FO2) and (FO3) synchronizing relays to wait further digit registration.

If the outpulsing is to start with the thousands digit (no code digits to be pulsed), the operation of (STG) relay connects the winding of the (FO1) relay through front contact of (SS), back contact of (IG5), front contact of (SO), back contact of (DL) to ground through back contacts of (LR2) and (STC). Thus (FO1) will operate unless either (DL) or (STC) is operated. (FO1) will operate (FO2) which releases (FO3), and the fundamental circuit will not be closed for trunk test until the thousands digit is registered, operating (DL), or (STC) is operated indicating that registration is completed or that the call has been abandoned.

If the outpulsing is to start with a code digit the above operating path for (FO1) is opened at back contact of (IG5) or front contact of (SO). The (FO2) relay is therefore not operated, and (FO3) is operated from ground at back contact of (FO2), through front contact of (RC). The fundamental will therefore be closed for trunk test as soon as (STG') operates. The complete path is then as follows:

For SXS outpulsing: "FT" lead is closed through back contacts of (MFF), (FTT), (AV2) and (AV), front of (FO3), back of (FO2) and (CFO), primary winding of (OF) shunted by its tertiary winding and (OFS) resistance, back of (FS1), winding of (TG) shunted by (TGS) resistance, front of (SS5), back of (OP2) and (CI2), front of (SS), back of (TCI), front of (STG') and (SS3), back of (AV), (FTT), and (MFF) to the "FR" lead.

For MF outpulsing; "FT" lead is closed through front contact of (MFF), winding of (MF) repeating coil, front of (MFF), back of (FTT), (AV2) and (AV), front of (FO3), back of (FO2) and (CFO), primary winding of (OF) shunted by its tertiary winding and (OFS) resistance, back of (FS1), winding of (TG) relay shunted by (TGS) resistance, front of (SS5), back of (OP2) and (CI2), front of (SS), back of (TCI), front of (STG') and (SS3), back of (AV) and (FTT), front of (MFF), winding of (MF) repeating coil, and front of (MFF) relay to "FR" lead.

With (STG') operated and (FO2) released, relay (CFO) is operated through front contact of (SS). The (CFO) relay by-passes the contacts of the (FO2) and (FO3) relays in the fundamental circuit, so that these contacts are no longer of any effect in closing or opening the fundamental circuit during out-pulsing.

The (TG) relay operates from battery and ground on the "FT" and "FR" leads, through the sender link to the trunk or repeater circuit. (TG) operates (TG1), which operates (TG2) unless (OF1) has operated due to incorrect polarity of the trunk battery and ground. (TG2) operates (O), (BO) and (FO), from ground through back contact of (FO2), front of (SS3), (TG2), and (STG), and back of (TCI). (O), (BO) and (FO) lock to ground at front contact of (FO8), which is operated through front contacts of (FO3) and (SS1). (FO) operates either (S1), (S2), (S3) or (S4), depending on the (IG5) and (SO) as described previously. Any one of these relays causes the operation of (FO2), which releases (FO3) and (FO8), followed by release of (O), (BO) and (FO).

The release of (FO) allows the (S1'), (S2'), (S3') or (S4') relay to operate in series with its associated counter and they lock. The operation of any one of these prime relays releases (STG) and (STG'), and operates (FS1) and (FS2) to transfer the fundamental circuit to the pulsing circuit. The TG relays release. The release of (STG') releases (FO2) which operates (RC), followed by (FO3) and (FO8). To prevent a momentary opening of the fundamental circuit by the release of (STG') before (FS1) has operated, a supplementary path around the (STG') contact in the fundamental is supplied through a front contact of (TG2).

START AND SYNCHRONIZATION OF OUTPULSING

START-PULSING SIGNALS

Outpulsing is started by the operation of the (SSP) relay.

When the outgoing trunk is connected to a step-by-step selector; this trunk is connected to give an ON-hook signal, that is, battery on the tip and ground on the ring. The (OF) relay is therefore not operated during trunk test. Following trunk test the (FS1) and (FO8) relays were operated. Operation of (FS1) operates (FS4) from ground through back contacts of (OF), (ROF), (FO7) and (RBS) and front contacts of (FS1) and (SS1), (SSP) then operates from ground through back contacts of (FO) and (LR2), front of (FS4) and (FO8) or (MFG), back of (AV1) and (SG).

If the trunk were reversed, giving an OFF-hook signal, operation of (SSP) is prevented by the operation of (OF). The sender then proceeds as described under Overflow and Telltale.

When the outgoing trunk is connected to a trunk which is associated directly or through a link or sender selector to a D.P. or MF sender (or register), the start-pulsing signal required is an OFF-hook followed by an ON-hook signal. For such direct sender calls the marker operates the reverse-battery-start relay (RBS).

On trunks used for completion of calls by operators the normal polarity of the trunk may in some cases by OFF-hook. In such case the receiving sender will also be connected with normal OFF-hook polarity, which will change to ON-hook when the sender is prepared to receive pulses.

On trunks used to complete calls originated by subscribers the normal polarity is usually ON-hook. In this case the receiving sender is seized with normal OFF-hook polarity, which changes to ON-hook when the sender is prepared to receive pulses.

The OFF-ON signal in the first case is called a "Delay-Dial" start-pulsing signal; the ON-OFF-ON signal in the second case is called a "Wink" start-pulsing signal. In either case the OFF-hook polarity operates the (OF) relay which operates the (ROF) relay through back contact of (WU), front of (SS5) and (RBS), back of (KP') and (FO7). When the (OF) relay releases on the ON-hook signal subsequent to the OFF-hook signal the (FS4) relay is operated through front of (ROF), (FS1), and (SS1).

SYNCHRONIZATION OF OUTPULSING

This sender is arranged for what is called delay-synchronization, - that is, a digit is not transmitted until the following digit has been registered, - or else, of course, all registration is completed. This latter condition is indicated by the operation of the (STC) relay.

On SXS calls the outpulsing of a digit is held up waiting the registration of the next digit (or else the completion of registration) by the operation of (FO2) and release of (FO3), which latter prevents the operation of (SSP).

On MF calls the outpulsing of a digit is held up waiting the registration of the next digit (or else the completion of registration) by holding a ground on the winding terminal number 5 of the (PGS) relay, which prevents this relay from pulsing.

In either of the above cases the circuit for delaying the pulsing of a digit is determined by a back contact of the "lock" relay of the succeeding digit - i.e., a back contact of (DL), (EL), (FL), (GL), (HL) or (STC) relays, as the case may be.

When pulsing starts with the "A" or "B" digit there is no delay, because the code has been registered before the marker was seized. The "C" digit, however, is not transmitted until the thousands digit or the start pulse has been registered. Double tandem operation with the code only (no numerals) is to be applied only with 3-digit codes. Thus for completion to repair clerk by double tandem connection, the full code 411 will be registered, even though the initial digit 4 might be a 2-digit code index.

PULSE GENERATOR CIRCUIT

step-by-step and MF pulse timing is controlled by the (PGS) condenser-timed relay. In series with its primary winding are the windings of the (PLS) and (CK) relays which operate and release with (PGS) during a series of pulses. Relay (PLS) furnishes out-dial pulses directly for loop pulsing, or operates (OPA) for battery-and-ground pulses and for MF pulses. Relay (CK) on SXS calls operates the counting relays to count the pulses as they are sent; on MF calls the (CK) relay advances the steering relays, (S1), (S1'), to (S8), (S8') for transmitting successive digits. When (SS1) operates on a SXS or MF call ground is connected to the windings of (PGS) and associated network to prepare the circuit for pulsing. (PLS) and (CK) operate, but the current through (PGS) primary winding is in a direction to cause its armature to move to its back contact. When relay (SSP) operates to start pulsing, ground is removed from the windings of (PGS), causing (PLS) and (CK) to release. After a timed interval (PGS) operates and (PLS) and (CK) reoperate. These relays will then release and operate in unison at time intervals determined by the constants of the network. Pulsing may be stopped by releasing (SSP) or by placing a ground on the No. 5 (negative) terminal of the primary winding of (PGS).

Three different networks are provided for use with the (PGS) relay to give three sets of timed intervals: (1) 10 pps with 63.5% break, for SXS loop pulsing; (2) 10 pps with 57% break for SXS battery-and-ground pulsing; and (3) 7.5 pps with 50% break for MF pulsing. Network (1) is provided with (SAB) and the (MF-) relays normal; network (2) with (SAB) operated, (MF-) relays normal; network (3) with (SAB), (MFC) and (MFE) operated. A fourth, long-pulse, condition is used for the initial "KP" pulse on MF pulsing; this pulse has a minimum length of 100 milliseconds, which is obtained by the use of an additional resistance (KP) in the network. This resistance is shunted out by the operation of the (KP) relay as soon as the "KP" pulse has been sent.

STEP-BY-STEP (D.P.) OUTPULSING

LOOP, COMPENSATED LOOP, OR BATTERY-AND-GROUND PULSING

Dial pulses may be transmitted in three different forms: Loop pulsing (loop-pulsing A); compensated loop pulsing (loop pulsing B), in which the sender includes a 1481-ohm resistance in the loop; and battery-and-ground pulsing.

For loop pulsing A the marker operates the (SSA) relay. The fundamental circuit is as follows: "FT" lead, back contact of (MFF), and (FTT) relays, front of (CFO), primary winding of (OF) shunted by its tertiary winding and (OFS) resistance, front of (FS1), and (SS3), back of (LR1), (MFF), and (SAB), front of (PLS), back of (MFA), (SAB) and (SSB) 300-ohm resistance (AM), back of (SSB), (SAB), and (MFF) to the "FR" lead. The 300-ohm (AM) resistance is shorted out during pulsing by a front contact of (SSP) and back of (FO5).

For loop pulsing B the marker operates the (SSB) relay. The fundamental circuit is as described for loop pulsing A except that (SSB) introduces a 1481-ohm resistance into the circuit during both the pulsing and interdigital intervals, and also provides a different resistance-condenser network bridging the pulsing contact of the (PLS) relay.

For battery and ground pulsing the marker operates both (SSA) and (SSB) relays, which operate (SAB) relay. In this case the fundamental is as described for loop pulsing A, except that (SAB) disconnects the (PLS) contacts from the fundamental and connects them to the winding of (OPA); the tip and ring leads of the fundamental being connected to the contacts of (OPA). These (OPA) contacts are then connected to contacts of the (OPC) relay, which when operated during the pulsing of a digit, connects battery through 210 ohms to the ring and ground through 210 ohms to the tip. During the interdigital intervals (OPC) is released, which bridges the tip and ring with a 250-ohm resistance.

PREPARATION TO TRANSMIT PULSES

When (SSP) operates to start the pulsing operation for a SXS call, the pulsing relays execute one pulse cycle with the fundamental circuit closed to provide a time interval for soaking the receiving circuit relays in the SXS repeater, selector, or sender before actual pulsing starts. This initial pulse is counted by the operation of the (FO6) and (FO7) relays as follows: When (SSP) operates (PLS) and (CK) release immediately and (PGS) starts to operate on its timed cycle. The release of (CK) removes a shunt from (FO6) which now operates and locks. When (PGS) makes its front contact (PLS) and (CK) reoperate and (CK) operates (FO7) which locks. The release of (PLS) did not transmit a pulse because its contacts were shorted by a back contact of (FO7). When the (FO7) operates this short is removed and when the (PLS) relay again releases a pulse will be transmitted to the "FT" and "FR" leads. (FO7) operated also closes a circuit from the back contact of (CK) to the counting relays for the purpose of counting the pulses.

Where (SAB) is operated indicating battery and ground pulsing (PLS) does not close the fundamental as for loop pulsing but operates (OPA). The first release of (OPA) operates (OPC) which is slow to release and holds during the train of pulses. (OPC)removes the bridge from the fundamental and connects battery and ground thereto. At the end of each pulse train (OPC) releases thereby removing battery and ground from the fundamental and restoring the bridge. (OPC) also short-circuits (OF).

For the loop pulsing class "A", with (SSA) operated, 300-ohm resistance (AM) is introduced into the fundamental following each train of pulses. This is necessary to prevent a possible singing condition of a voice repeater in route, particularly when the loop between the sender and repeater is short.

COUNTING SXS PULSES

When (PLS) and (CK) release to transmit the first pulse, - following the operation of (FO7) - a counting relay circuit is closed from the back contact of (CK), front of (FO7) and (SS1), back of (6') and (1') counting relays, back of (FO5) and back contacts of steering relays to the front contact of the steering relay which was operated on trunk test, - either (S4), (S3), (S2), or (S1).

From the steering relay the counting relay operating path continues to the (D) register from (S4), or the A, B or C registors from (S1), (S2), or (S3), respectively. At the register connection is made to a counting relay, as follows:

Digit Registered	Counting Relay Connection	
1	0	
2	1	
3	2	
4	3	
5	4	
6	0)	With "high-five" connection.
7	1)	
8	2)	
9	3)	
0	4)	

When the code digits are to be transmitted as registered on the A, B, and C registers the counting relay connections are made through front contacts of (CCC), (RCP), (RCQ) and (RCR) relays. When the code digits are converted to other values the counting relay connections are made through back contacts of (CCC), and the contacts of the (OB-), (OG-) and (CR-) relays.

The counting relays (4) to (1) are counted down in the usual manner. When 1' counting relay is operated, or if the connection is for the (0) counting relay (digit 1 or 6) the counting relay path is again carried through chain contacts on the steering relays to the register, where connection is made to the (0) counting relay for digits 1 to 5, or to the (6) counting relay for digits 6 to 10.

MEASURING THE INTERDIGITAL INTERVAL AND ADVANCE TO NEXT DIGIT

An interval of approximately 0.6 second is measured between digits, - that is, from the last pulse of any digit to the first pulse of the succeeding digit. This interval is obtained by counting 5 pulses on the counting relays, plus the necessary local relay operating time required. The fundamental circuit is held closed during this interval by a make contact on (FO5) which shunts the pulsing contact of (PLS). With (FO5) operated the counting path from (CK) is disconnected from the steering relays and connected directly to the number (4) counting relay, to count 5 pulses.

The circuit operation is as follows: At the last pulse of any digit (FO) operates, which releases (SSP) to stop the pulsing, and also operates (FO4). (FO4) operates (FO2), releasing (RC) and (FO3), which releases (FO8). With (FO3) and (FO8) released all counting relays are released. Release of (FO) allows (FO5) to operate in series with (FO4); this releases (FO2), causing the operation in succession of (RC), (FO3), (FO8) and (SSP).

The operation of (SSP) starts the pulse generator circuit to count 5 pulses, operating (FO), which releases (SSP) at the end of the fifth pulse. (FO) also shunts down (FO4). With (FO5) still operated this connects ground through back contacts of a chain circuit on the steering relays, starting at transfer contact of (S7') to a front contact of the operated steering relay for the digit which has just been pulsed. This front contact is connected to the steering relay pair for the next digit to be sent. The counter relay of this pair operates. A ground originating at front contact of (DRL) hereupon operates (FO2), through front contacts of the prime relay of the steering pair for the digit previously transmitted, front contact of the counter relay just operated for the next digit, front of (FS1), back of (MFD) and (XB), and front of (SS1) to the winding of (FO2). Operation of (FO2) releases (RC) and (FO3), which releases (FO8), thus releasing all the operated counting relays. Release of (FO) releases (FO5) which allows the operation of the prime steering relay in series with its counter steering relay, for the digit next to be pulsed. The operation of the prime steering relay releases the pair of steering relays which were used for the previous digit. This releases (FO2), unless it is held operated, waiting further registration, by the synchronization circuit. When (FO2) releases it operates in succession (RC), (FO3), (FO8) and (SSP), to start pulsing the next digit.

SYNCHRONIZATION DELAY CIRCUIT

The operation of the (SSP) relay to send any digit from the "C" digit to the stations digit is delayed until the succeeding digit is registered or the start pulse is received. This is done by holding the (FO2) relay operated by ground through back contacts of the digit register lock relays or the (STC) relay, as follows:

Next Digit to be Sent	Steering Relay	Normal Contact Controlling Release of (FO2)
C	S3	DL or STC
D (Thousands)	S4	EL or STC
E (Hundreds)	S5	FL or STC
F (Tens)	S6	GL or STC
G (Units)	S7	HL or STC
H (Stations)	S8	STC

The delay circuit is also opened by operation of the (LR2) relay when this relay operates on an abandoned call or by sender time-out.

STOP-GO SIGNAL

On a call to step-by-step selectors which may connect to a dial-pulse terminating sender after one or more digits have been sent, it is necessary to stop pulsing until such sender is properly connected and in condition to receive pulses. It is necessary to send a reversed battery on the fundamental tip and ring (OFF-hook signal) into this tandem sender, in order to stop further pulsing until the terminating sender is ready, at which time the fundamental circuit polarity is restored to normal (ON-hook) as a "Go" signal to the tandem sender to resume pulsing.

When the (OF) relay operates due to the reverse battery received in the interdigital interval following any digit up to the tens digit, the (SG) relay is operated through back contact of (WU), front of (SS1), back of (RBS), and front (FO7). Operation of (SG) releases (SSP) which stops further pulsing of the interdigital timing interval. When the (OF) relay releases by return of the trunk polarity to normal on-hook condition the (RBS) relay is operated, which reoperates (SSP) and the pulsing continues.

When the (RBS) relay is operated by the marker on a SXS call direct to a sender this Stop-Go feature is not in effect.

COMPLETION OF SXS CALL

When the last registered digit has been outpulsed the (AV) relay is operated to cause the tandem trunk to be cut through and the sender to be restored to normal.

On completion of the pulsing of any digit the (FO) relay operates (FO4) relay. This connects a ground through a front contact of (STC), the steering relay (S-) used for the digit just sent, and a back contact of the lock relay for the succeeding digit register, to the winding of the (AV) relay. The (AV) relay will therefore operate if two conditions exist, - namely, no number is registered on the succeeding digit register (lock relay not operated), and registration is completed (relay (STC) operated).

The combination of steering relays and lock relays for each digit is as follows:

Last Digit Sent	Steering Relay	Digit Register Lock Relay Non-operated
B	S2	DL (See Note)
C	S3'	DL
TH	S4'	EL
H	S5'	FL
T	S6'	GL
U	S7'	HL
STA	S8'	-

Note - The first case above is a special case where the call ends with the sending of the digit on the "B" register: This is the transmission by dial pulses of a two-digit TX code. The (DL) contact is in the (AV) operating path but this case also includes a front contact of (11B) relay connected by "S" wiring (two-digit TX code option) to the (S2) steering relay.

The operation of (AV1) by (AV) opens the operating path to the (SSP) relay, so that the pulse generator circuit can no longer be activated.

MF OUT PULSING

MF PULSES

Numbers are transmitted by multi-frequency pulsing by transmitting for each digit a pulse consisting of two alternating current frequencies. The duration of each pulse is approximately 65 milliseconds with an open interval between pulses of 65 milliseconds. Each number, comprising one to eight digits, is preceded by a KP (gate-opener) pulse, and is followed by a start (ST) pulse. The KP pulse is of longer duration than the digit pulses, and is used to activate the receiving circuit to the condition for registration of the digit pulses which follow.

Digit	Frequencies, c/s
1	700, 900
2	700, 1100
3	900, 1100
4	700, 1300
5	900, 1300
6	1100, 1300
7	700, 1500
8	900, 1500
9	1100, 1500
0	1300, 1500
ST	1700, 1500
KP	1700, 1100

Each pulse is transmitted as a combination of two different frequencies, selected as required from six supply leads designated 0, 1, 2, 4, 7, and 10, cable into the sender from the MF Current Supply and Distribution Circuit.

The MF pulses are transmitted to the outgoing tip and ring leads, FT and FR, through the output coil (MF). The (MF) repeating coil is included in the fundamental circuit as previously noted. The primary of this coil is connected to two leads carrying the required frequencies for any digit by one of relays (MF1), to (MF5), together with either the "above 5" or the "below 5" relay (MA5) or (MB5).

The frequencies used and (MF-) relays operated for each digit are as follows:

MF Relays Operated	MF Supply Circuit Leads Connected
MF1, MB5	0, 1
MF2, MB5	0, 2
MF3, MB5	1, 2
MF4, MB5	0, 4
MF5, MB5	1, 4
MF1, MA5	2, 4
MF2, MA5	0, 7
MF3, MA5	1, 7
MF4, MA5	2, 7
MF5, MA5	4, 7
None	10, 7
KP Normal	10, 2

OPERATION OF MF PULSING CIRCUIT

When the (SSP) relay operates, following receipt of the reverse-battery start-pulsing signal, ground is removed from the common point of the primary and secondary windings of the (PGS) relay to start pulsing. If the MF pulsing is to start with the C digit another ground path may be closed through normal contact of (DL), waiting registration of the thousands digit or start pulse. When both ground paths are open (CK) and (PLS) release immediately and (PGS) starts its timed operate interval. Release of (CK) removes a shunt on (FO6), which operates and locks. Release of (PLS) operates (OPA) through front contacts of (MFE) and (SAB). This connects the KP signal to the MF output coil, through front contacts of (MFF), (SAB), (OPA), (SSA) and (MFA), and back contacts of (KP).

When (PGS) operates, (PLS) operates, which releases (OPA), terminating the KP pulse. Relay (CK) also operates. When (OPA) back contacts close, (KP) is operated through front contacts of (SS), (CK), (FO6) and (MFE), back of (OPA), front of (CKM) and back of (KP') to (KP) winding. (CKM) was operated through back contact of (KP) when (MFE) operated. The (KP) resistance in the MF pulsing network is shorted out by the operation of (KP), to increase the pulsing speed to its normal digit-pulsing value. (KP) also shunts out the front contacts of (MFE), (FO6), (CK) and (SS) by which (KP) was operated, so that the operation of (KP') now depends on the reoperation of (OPA), and is independent of the (CK) relay contact.

The operation of (KP) operates one of the (MF1) to (MF5) relays as required for the first digit to be out-pulsed. The (MF1) relay operates from ground at front contact of (MFE) through back of (STG), front of (KP), chain contacts of the (S-) steering relays to the front contact of the steering relay which was operated during trunk test, thence to the register corresponding to the operated steering relay, contacts of the register, front contact of (MFC) to the winding of the required (MF1-5) relay. Relay (MA5) or (MB5) was previously operated through contacts of the digit register when the steering relay was operated. The operation of one of the (MF1) to (MF5) relays, and either (MA5) or (MB5) relays close the proper two frequencies to the contacts of the (OPA) relay, in preparation for the digit to be sent on the next operation of (OPA).

The (PGS) relay releases after its normal interdigital time interval, releasing (CK) and (PLS). Release of (PLS) operates (OPA) to send the first MF digit. (DP') operates in series with (KP).

The first digit pulse is terminated by the release of (OPA) when (PGS), (PLS) and (CK) reoperate. Release of (OPA), terminating the pulse, also causes the operation of the next steering relay, through front contact of (KP), (CKM) and (KP') to chain contacts of the steering relays, beginning with (S7'), then (S6'), etc., to the front contact of the operated steering relay for the digit just transmitted.

The operation of this succeeding steering relay opens the paths to the (MF1) to (MF5) and (MA5) and (MB5) relays, and closes new paths to those relays through the next digit register. When (OPA) again operates at the end of the pulse open-interval the two frequencies required for this digit are transmitted.

The transmission of digit pulses continues in this way for as many digits as are registered. When a digit register is reached on which no number is recorded, then at this point a start pulse is transmitted and the call is completed.

TRANSMISSION OF START PULSE AND COMPLETION OF CALL

When the start pulse is received in any register position only the number 7 relay will be operated in this digit register, and the corresponding lock relay for this digit will not be operated. Therefore when the steering relays advance to this register, as described above, there is no path through the register relays for the operation of one of the (MF1) to (MF5), and (MA5) or (MB5) relays. The two frequencies representing the start pulse are therefore connected to the pulsing contacts of (OPA) through back contacts of these (MF-) relays. The start pulse will therefore be transmitted when the steering relays advance to the first digit for which the lock relay is not operated. When the (OPA) relay releases to terminate the start pulse, (AV) is operated from ground through front contact of (SAB), front of (PLS) and (MFA), back of (OPA), front of (MFB), (STC) and prime steering relay, and back of register lock relay. The corresponding lock and steering relays for the operation of (AV) are: (DL) and (S4'), (EL) and (S5'), (FL) and (S6'), and (GL) and (S7'). The operating path for (AV) following the transmission of the stations digit and start pulse is from ground through front contacts of (SS), (CK) and (FO6), back of (OPA), front of (CKM) and (KP'), back of steering relays (S7') to (S1'), front of (KP') to winding of (AV).

The operation of (AV) operates (AV1) which releases (SSP). Operation of (AV1) causes the tandem trunk to be cut through and the sender to restore to normal.

SYNCHRONIZATION OF OUT PULSING WITH DIGIT REGISTERATION

Out pulsing of any digit is delayed until the succeeding digit is registered, or else the (STC) relay is operated indicating the completion of registration.

At the end of the interdigital open interval for any digit the release of (PGS) will normally release (PLS) and (CK). However, a synchronizing ground may be applied to the junction of the primary and secondary windings of (PGS), which will prevent the release of (PLS) and thus prevent transmission of the next pulse. The normal contacts of the digit lock relays which supply this ground for the various digits is as follows:

Next Digit to be Sent	Steering Relay	Normal Contact Preventing Next Pulse		
C	S3	DL	or	STC
D	S4	EL	or	STC
E	S5	FL	or	STC
F	S6	GL	or	STC
G	S7	HL	or	STC
H	S8	STC		

Pulsing is prevented also by ground supplied from a front contact of (TN) on sender time-out; from front contact of (OE) due to error in registration; or from back contact of (CKM) due to error in operation of the (MF1) to (MF5) or (MA5) and (MB5) relays.

DIGIT-RECAPTURE CHECK CIRCUIT

The MF pulse transmitted for any digit requires the operation from the digit register of one of the (MF1) to (MF5) relays together with either (MA5) or (MB5). To check this requirement the (CKM) relay is operated through a contact chain on (MF1) to (MF5), in series with contacts on (MA5) and (MB5). Relay (CKM) will be operated if one and only one relay (MF1-5) is operated, with either (MA5) or (MB5) operated. Relay (CKM) will also be operated if none of these seven relays are operated, which is the condition for transmitting the start pulse.

Relay (CKM) is sufficiently slow so that it will remain operated while one set of (MF-) relays is releasing and the next set is operated, upon the operation of a steering relay transferring these relays from one digit register to the next. If at any register one relay is not operated because of an open wire or defective contact,. or if a relay is operated falsely due to a trouble ground or cross, then (CKM) will release and stop the pulse generator relay (PGS) from operating. The sender will time out and send a reorder signal to the originating end.

SENDER RELEASED AFTER SERVICE OR TEST OS 76, 76-1

When a connection has been established or a test completed the release of sender and link is caused by the operation of (AV4) which with (SR1) released opens the circuit holding (ON1) and (ON2) locked to each other. The operation of (AV4) depends upon the prior operation of (AV1).

On a completed revertive pulse call to panel or crossbar the operation of (FO) following reversed battery operates (AV) followed by (AV1). The trunk (D) relay operates, operating (CK1) which operates and locks (CK2). This releases the trunk (T) relay, releasing (CK1) which permits (CK3) to operate. Trunk closure is maintained from the operation of the trunk (D) relay until it releases. (CK3) operated releases slow release relay (CK4) permitting (AV4) to operate. (CK4) is slow release to allow time for the operation of trunk (A) relay. The operation of (AV1) removes ground from the contacts of (L) permitting (SR) and (SR1) to release early.

On a CI call (AV) and (AV1) operate following (U') if a heavy positive pulse is not required, or following the release of (PG2) if a heavy positive pulse is required. Subsequent operations are as described above.

On an out-dial-pulse call (SXS), the (AV) relay is operated as soon as the last registered digit is transmitted. On an out-MF pulse call, (AV) is operated immediately after the start pulse is sent.

If a call is abandoned (LR1) and (LR2) and (LR2A) are operated and locked up. The sender proceeds with its operations up to a certain point depending on the conditions until finally (AV1) is operated. With (LR1) operated the ground which grounds the "D" lead to operate the (D) relay in the trunk is switched to the (AV2) releasing slow-release (AV3). On revertive pulse calls trunk closure is applied through resistance (AA) by the operation of (AV2) until (AV3) releases, when ground from its back contact operates (AV4) through a front contact of (AV1). The release of the sender is delayed until (CK4) releases, following the operation of (AV4).

OVERFLOW AND TELLTALE OS - 76

Reverse battery may be received over the fundamental tip and ring leads: (a) as a start-pulsing signal, - when followed by normal polarity, - on MF or direct sender SXS calls; (b) as a stop-pulsing signal when first received after pulsing has started on a regular SXS call; or (c) as an incoming-advance signal when received after completion of pulsing on a revertive pulse call.

If reverse battery is received under any other conditions than these it is treated as an overflow signal. The action of the sender on an overflow signal depends upon the class of call.

MF OR DIRECT SENDER SXS CLASS

As previously described, reverse battery (off-hook) followed by normal battery (on-hook) is required as a start-pulsing signal. Following the start of pulsing either the (KP') or the (F07) relay is operated. If a second reverse battery occurs, due to a reversed trunk, sender reorder signal, or other cause, the operation of (OF) operates (OF1) through front contact of (KP') or (F07). (OF1) operates (SOF), which locks, prevents the operation of (AV2), and operates (TR1) on first trial calls, or (TR3) on second trial calls. In either case (DST) and (DRL) are released, releasing all selection register relays locked to (DST) or supplied with off-normal battery by (DST), including (OF). The release of (OF) releases (OF1) which releases (SOF). (SOF) released allows (TR2) or (TR4) to operate and a marker is then called in for a second or third trial.

The (OF1) relay operating path is opened by a back contact of (WU), so that a reverse battery is not recognized after the pulsing of the tens digit. This is to avoid a possible false overflow indication by the operation of the (OF) due to a surge condition at the cut-through of the terminating trunk.

SXS CALL THROUGH SXS SWITCHES ONLY, OR TO SXS SWITCHES AND A SENDER

The operation of the (OF) relay after pulsing has started stops the pulsing as described previously. However, if the initial trunk polarity is not correct, due to reversal of the tip and ring leads in the trunk or distributing frame connections, the (OF) relay will operate on trunk test, before pulsing starts. (OF1) and (SOF) will be operated, resulting in a second or third marker trial as described above.

If the terminating sender should return reverse battery to the tandem sender after the operation and release of (OF) as a stop-go signal, then a second operation of (OF) prior to pulsing the tens digit will operate (OF1) and result in another trial. The operating path for (OF1) is opened by the operation of (WU) which operates from (S4). Therefore no test for tip and ring polarity is made between tens and units selections.

If no terminating sender is involved, a reverse battery encountered after the first step-by-step selection has been made will operate relay (SG) to stop the pulsing. If the reverse battery is continuous the tandem sender will time out. If the reverse battery is momentary the pulsing will continue; but if it is intermittent the second operation of (OF) will operate (OF1) resulting in a second or third trial.

REVERTIVE PULSE CALL

Reverse battery in any position of the sender except incoming advance is treated as an overflow signal. It may be caused by an incoming selector in a panel office running to overflow because all final selectors are busy, or an incoming or final running to telltale because of trouble, or by a crossbar sender running to telltale, or by a trunk to PCI or operator having its conductors reversed. Briefly stated, the action of the sender is to put the offending selector or sender in the way of returning to normal, to restore the selection register and selection sequence circuit to normal and to call a marker to break down the connection forward and make another trial.

The action of a panel selector, terminating sender or R.P. tandem sender when it runs to telltale varies with the different conditions, but in general it connects reverse battery to the fundamental and recognizes a closure, then it connects direct battery to the fundamental and recognizes a second closure commonly known as trunk closure and then it returns to normal.

In some cases the distant circuit holds the reverse battery on the fundamental for a definite time after recognizing the first closure and then it breaks it off of its own accord. In other cases it holds it on until the sender breaks the fundamental closure. In "office telltale," "office overflow," and "incoming brush telltale" the sender does not wait for the opening of reverse battery but opens the fundamental when (OF2) releases if (STP) is operated. On incoming group and final selections (OF2) is held operated from back contact of (S3) through front contact of (FS1) and back of (MFC).

If a distant office selector runs to overflow in hunting for a CI trunk or if a trunk to CI which has its conductors reversed is seized, the sender at that time will be in trunk test position with (TG) and (OF) in the fundamental. They will both operate on the reversed battery. (TG) operates (TG1) and (TG2) but without further effect since (OF1) breaks the (AV) path. (OF) locks and operates (OF1) through front contact of (STG') and back of (FS1), (SS5) and (WU). (OF1) closes a circuit to operate (IA), and shunts (TG), lowering the resistance of the fundamental to operate a relay in the distant office selector. The early closing front contact of (IA) is ineffective because (STP) is not operated, but its late closing front contact operates (O), through a front contact of (TCI), (OF2) and (OF1). (OF1) releases (OF2) which allows (BO) and (FO) to operate followed by (FO1) and (FO2). (BO) opens the fundamental. The fundamental thus remains closed during the release time of (OF2), thereby insuring the operation of relays in a two-wire office or tandem R.P. sender. (FO2) operated releases (FO3) which releases (O), (BO), (FO), (FO1) and (FO2). During the time (FO2) was operated (AV2) operates and locks to start the trunk closure cycle followed by the recall of a marker, as described later.

If a panel office selector runs to overflow in hunting for an incoming selector, the sender at that time will be in trunk test position with (TG) or (MTG) and the 14,500-ohm resistance in the fundamental. (OF) is short-circuited to prevent its possible operation at this time when the fundamental bridge is too high in resistance to be recognized by the distant circuit as a closure. (TG) or (MTG) will operate on the reversed battery and the sender will advance to the incoming brush position where (STP) and (OF) are in the fundamental. They will both operate on the reversed battery. (OF) locks up and it operates (OF1) through back contacts of (STG'), (SS5) and (WU). (OF1) closes a circuit to operate (IA). The early closing front contact of (IA) operates (O), and after a short interval slow relay (OF2), its operating path broken by the operation of (OF1), releases and breaks the circuit from the contact of (STP), thereby allowing (BO) and (FO) to operate.

If a panel incoming selector runs to overflow in hunting for a final selector, or if an office, incoming or final selector, a terminating sender or R.P. tandem sender runs to telltale, the sender at that time will be in some selection position with (STP) and (OF) in the fundamental. They will both operate on the reversed battery. (OF) locks up and it operates (OF1) through back contacts of (STG'), (SS5) and (WU). (OF1) closes a circuit to operate (IA). The early closing front contact of (IA) operates (O), and when the distant selector breaks off the reversed battery and releases (STP), or when (OF2) releases as in the preceding paragraph, whichever occurs first, (BO) and (FO) operate. The late closing front contact of (IA) serves to insure the operation of (O), (BO), and (FO) in the case of ground cut-off incoming selectors giving a very short pulse of reversed battery as described for incoming advance.

When (OF) operates in any of the conditions described in the preceding subsections it operates (FO1) through front contact of (OF1) and back contacts of (LR1) and (LR2A). (FO1) operates (FO2) and that releases (FO3). (FO2) breaks the fundamental, if (BO) has not already done so, to give the signal required in some cases for the distant selector to apply direct battery. (FO2) operating operates (AV2) which locks up. The operation of (AV2) and the release of (FO3) remove all grounds holding (O), (BO) and (FO) and they release. The release of (FO) is followed by the release of (FO1) and (FO2).

The operation of (AV2) and release of (FO2) bridges 500-ohm resistance (AA) across "FT" and "FR" to serve as trunk closure for the distant selector or sender and breaks off the "FT" lead from the fundamental circuit to prevent (STP) or (TG) from operating on the trunk closure. The release of (FO2) after the operation of (AV2) breaks the operating circuit of slow relay (AV3) and that releases after an interval allowed for the trunk closure to be effective.

The release of (AV3) with (AV2) operated following trunk closure operates the (TR1) or (TR3). This causes the release of (DST) and (DRL), all selection register relays locked to (DST), and all relays fed by off-normal bettery including (OF). (OF) releases (OF1) which in turn releases

(IA) and (AV2) and the release of (AV2) removes the ground shunting (TR2) or (TR4). The marker is then called in for a second or third trial.

CI CALL

Test of the polarity of a call indicator trunk is made by the (OF) relay during trunk test. If reversed battery is received both (TG) and (OF) will operate. (OF) operates (OF1) which releases (OF2) and operates (IA). (TG) operates (TG1), but (OF1) prevents the operation of (CI1). Operation of (IA) operates (BO), (FO) and (O). (FO) operates (FO1) which operates (FO2). (FO2) opens the fundamental circuit, releases (FO3) and operates (AV2). When slow release relay (OF2) releases with (FO3) released the (BO), (FO) and (O) relays release. (FO) releases (FO1) which releases (FO2). With (AV2) operated and (FO2) released (AV3) releases. A momentary trunk closure is applied to the fundamental circuit during the release time of (AV3). With (AV3) released and (AV2) operated (TR1) or (TR3) is operated, releasing (DST), which releases (STG) (STG') and (OF). (OF) releases (OF1) which releases (AV2). (TR2) or (TR4) then operates, operating (DST) for a second or third marker trial.

ABANDONED CALLS OS - 76

This section describes the procedure in case the "T" and "R" leads are opened before the sender has completed its normal functions on a call. If the train of connections to the called line has been partly built up, it is necessary that steps be taken to restore all selectors to normal. The procedure depends upon the class of call and the stage to which it has advanced when it is abandoned.

When the calling subscriber has hung up long enough to release (SR), (LR1) operates through a front contact of (ON2) and back contacts of (SR) and (L). (LR1) operates (LR2), when (SR1) has released, and (LR2) operates (LR2A) and also (STC) as if registration had been completed. The operation of the (LR) relays leads to the operation of (AV) as described in the following sections. (LR1) opens the operating path for (SR) and also releases (RV1) unless this relay is held by the "RV" class-of-service cross-connection.

CALL ABANDONED BEFORE MARKER IS ENGAGED

If the call is abandoned before the sender has engaged a marker, no connection has been made through the switches and there is no reason why the sender should not be disconnected at once. If a marker has been used and dismissed but (DRL) is momentarily normal preparatory to a second trial caused by an overflow condition or trouble release there may be a connection built up to a distant selector but the latter has been put in condition to return to normal so it is still true that the sender may be disconnected at once. If (DST) has been operated but due to marker delay no marker has been engaged, a holding ground for relay (SR1) is not closed in the marker connector and (SR1) is permitted to release. If a marker is engaged (SR1) is held. When (SR1) releases (LR2) operates and removes battery from the "CBS" lead. With (LR2) operated and (DRL) normal, (AV) operates.

CALL ABANDONED WHILE MARKER IS ENGAGED

When a marker is engaged it operates (DC); then operates (DRL), then establishes connection to a trunk, and finally releases (DC). Until the marker connector is released (LR2) cannot operate because (SR1) is held. After the connector breaks down relay (LR2) may operate with results as outlined below.

CALL TO CROSSBAR OR PANEL ABANDONED

The sender completes any distant office selections in the route, makes trunk test and attempts incoming brush selection; or if the call has progressed beyond that point before being abandoned attempts the next selection in order. Neither trunk test nor any selection is delayed for registration because the paths which ordinarily delay the release of (F01) and (F02) are opened by the operation of (LR2).

A front contact of (SR1) released breaks the circuit from the contact of (STP) at a point such that while there is no interference with distant office selections an incoming or final selection cannot operate the zero counting relays, so the attempt to make such a selection sends the selector to telltale.

The distant incoming selector sends a pulse of reversed battery over the fundamental, the sender recognizes it by operation of (OF), and then the sender makes trunk closure.

On a reverse battery signal caused in any way except by an abandoned call or a timed-out sender, the trunk closure is followed by the recall of a marker to make another trial. With (LR2) operated, however, the release of (AV3) with (AV2) operated causes (AV) to operate through a make of (LR2), to release the sender.

CI CALL ABANDONED

On abandoned CI calls where the (TW) relay is operated: in order to restore any distant office selector or tandem sender which may have been seized and to satisfy a CI operator who may have been signaled, the sender is allowed to proceed with its regular functions to the end, but as far as possible zeros are substituted for the registered digits in the transmission of CI pulses.

The sender completes any distant office selections in the route, makes trunk test, awaits assignment and then sends out the CI pulses and operates (AV) in the usual manner. Trunk test is not delayed for registration because the operation of (LR2) breaks the path which delays the release of (F01). All digits transmitted after the operation of (LR2A) are sent as zeros because the operating paths of (PT) and (PR) are broken at contacts of (LR2A). If registration has not progressed far enough to operate either (STA)-(STA') or (STB)-(STB'), the latter pair will be operated through front contact of (CI1) and back of (STA'). This is to prevent the sending of nine digits.

If the assignment is delayed to such an extent that the sender reaches the stuck sender position without assignment having been made, (AV) will then operate by a path through back contact of (SR1), front of (TG1) and front of (CI), to off-normal ground through front of (TN).

If the (TW) relay is not operated then it is not necessary to wait for assignment of the call in order to avoid leaving connecting equipment off normal, so as soon as the sender makes trunk test the (AV) relay operates from a front contact of (STG'), back contact of (TW), front contacts of (CI) and (TG1) and back contacts of (SR1) relay. This is to extinguish the trunk lamp at the operator's position as soon as possible.

STRAIGHTFORWARD CALL ABANDONED

The sender simulates trunk test for a local straightforward call and that operates (AV) in the usual way. (AV2) operates followed by the release of (AV3) which operates (AV4). Simulated trunk test is not delayed for dialing because the path which ordinarily delays the release of (FO1) is broken by the operation of (LR2). For straightforward class through a second tandem the call is allowed to proceed with trunk test in the regular manner, followed by trunk closure in order to restore the tandem apparatus. When (AV3) releases, (AV4) operates to restore the sender.

MF OR SXS CALL ABANDONED

On an abandoned MF or SXS call (LR2A) operates (AV) through front contacts of (SS), and (LR2) releases (SSP) to stop outpulsing.

SENDER RESEIZED WHILE STILL ENGAGED AFTER AN ABANDONED CALL

If a sender is reseized during the process of restoring, after an abandoned call, it is necessary to prevent the transmission of a false start-pulsing signal during the release of the sender. In order to accomplish this, on calls from senders the (RV1) relay is held operated through the contacts of the operated CS- relays until the sender restores the trunk apparatus. On other classes the (RV1) relay is released to restore the normal battery and ground polarity to the "T" and "R" and then the sender restores the trunk apparatus before the "T" and "R" leads are opened. With (LR1) and (CK4) operated ground is connected to the winding of (ON2) thereby providing an independent holding circuit for (ON2). The operation of (AV4) opens the "CO" lead to restore the trunk and opens the circuit for slow release relay (CK4). When the latter releases the sender restores to normal.

TIMING CIRCUIT OS - 78

This section describes the timing circuit and the procedure in case of permanent signal, partial registration, stuck sender, waiting assignment, and the timing in connection with reorder signal sent to the originating end as a result of operation of the "operator error" relay (OE), or of the "RO" relay. Time is measured by a timing interrupter which has a 20 second cycle, closing its contact for 10 seconds and breaking it for 10 seconds.

MEASUREMENT OF TIME INTERVALS

Whenever ground is connected to the interrupter, the (TM) relays being normal, (TM1) operates at once or as soon as the interrupter closes. (TM2) operates on the first break following, (TM1) releases on the second closure and (TM2) releases on the second break. This 40 second cycle repeats as long as the interrupter is kept grounded.

(TM3) and (TM4) are actuated by a front contact of (TM2). (TM3) operates in from 0 to 20 seconds after the connection of ground to the interrupter. (TM4) operates 20 seconds later and locks up, and (TM3) releases after 20 seconds more.

The ground connected to the interrupter is also the locking ground for the (TM) relays and whenever it is broken all the operated (TM) relays release.

TIMING FOR REGISTRATION TO START

When the sender is seized the timing circuit starts to measure a period of from 20 to 40 seconds. If the first digit is registered in that time the timing circuit is restored and starts again. Otherwise a reorder signal is returned for 10 seconds and then the trunk is set in the "no connection" condition and the sender is dismissed. If the sender fails to release within 10 seconds the stuck sender lamp is brought in.

The interrupter is connected to an off-normal ground lead through back contacts of relays (AL1) and (STS). As soon as the sender link operates a frame relay or class-of-service relay the off-normal ground lead is connected to ground in the link control circuit and the (TM) relays start to function. The off-normal ground is continued from a front contact of (ON1) until the sender is released.

If a digit is registered in time on the (A) register, (AL1) operates from front contacts of the (A) relays, to lock up for the remainder of the connection. (AL1) breaks ground from the interrupter, and any operated (TM) relays thereupon release. When they are normal (AL2) operates to lock up for the remainder of the connection unless (STS) should be operated.

If a digit is not registered in time (TM4) operates and locks, and operates (REG) and that in turn operates (TN) which locks and closes battery to the (FL) interrupter. (PU1) operates on the back contact closure of the interrupter and (PU2) on the front, and both lock. Thereafter (RV2) follows the back contact closures and operates and releases (RV1) which reverses "T" and "R" to flash the originating end; tone is also applied to the trunk during each operation of (RV2).

If the sender is not released 10 seconds after (REG) and (TN) operate (TM1) will operate and (STS) then operates through back contacts of (AL2) and front contacts of (TM1) and (TN). (STS) locks and operates (AV). If the sender fails to release as a result of the operation of (AV), (TM3) and (TM4) will release in 10 seconds and light the stuck sender lamp.

TIMING FOR COMPLETION OF REGISTRATION

When the first digit has been dialed the timing circuit starts again to measure a period of from 20-40 seconds. If (STC) operates in that time due to completion of registration or abandonment of the call, (ST1) operates from a front contact of (STC). (ST1) breaks ground from the interrupter and any operated (TM) relays release. When they are all normal (ST2) operates to lock up for the remainder of the connection unless (STS) should operate.

If registration is not completed in time (TM4) operates and locks and causes (REG) to operate. (REG) in turn causes (TN) to operate and send reorder flash and tone to the originating end. (REG) also operates the partial dial register. The timing continues and if the originating end does not disconnect and release the sender in 20 seconds the following action takes place.

The reoperation of (TM1) and (TM2) at the end of another 20 seconds causes (LR2) to operate, which operates (LR2A). This results in the operation of (AV) and the disconnection of the sender under various conditions as follows:

The operation of (LR2) simulates the completion of registration by operating (STC).

(LR2) prevents the seizure of a marker if it has not already been connected; (LR2) will release the marker connector if it is still attached. If the (DRL) relay is not operated no outgoing trunk connection has been made, and (AV) is operated immediately from front contact of (LR2A) and back of (DRL). All partially registered codes, including operator codes, disconnect in this way.

On MF or SXS calls, (AV) is operated immediately from front contacts of (LR2A) and (SS).

On panel or crossbar calls the sender completes any revertive pulse office selections in the route, makes trunk test, and continues incoming and final selections as far as registration has been completed. Neither trunk test nor any selection is delayed for registration, because the paths which ordinarily delay the release of (FO1) and (FO2) are opened by the operation of(LR2). However, at some point the incomplete digit registration will result in failure to close a counting relay path for some selection, and the panel selector or crossbar terminating sender will be sent to telltale. The resultant reverse battery signal from the terminating end operates (OF) and (STP), which operate (OF1) and (FO). This causes the operation of (AV) from front contact of (FO), back of (SS1), front of (OF1), back of (LR1), and front of (LR2A). This differs from the action on an overflow or telltale due to trouble, in which case (FO2) operated and caused the operation of (AV2) for a second trial, as previously described.

On a call indicator class the (AV) relay is operated as described for abandoned calls.

Operation of (AV) by any of these paths causes(AV1) to operate. This operates the trunk (D) relay, and the sender disconnects as on a completed call. The trunk provides the trunk-closure for any terminating trunk connection which may have been set up

If the sender is not released in 10 seconds more, (TM1) releases and operates (STS). (STS) provides another path for the operation of (AV) through back contacts of (CP) and (ST2).

If the sender is not released in 10 seconds following the operation of (STS), (TM2) releases, which releases all the (TM) relays, and lights the stuck sender lamp through back contact of (TM4) and front of (STS).

STUCK SENDER

When relay (ST2) operates on the restoration of the timing circuit after the completion of registration it grounds the interrupter and so starts the (TM) relays on another cycle for stuck sender timing.

If the (TW) relay is operated the time for operation of the (TN) relay is extended to 60-80 seconds. The operation of the (TM) relays then is as follows: In 0 to 20 seconds (TM1), (TM2) and (TM3) are operated. In 20 to 40 seconds (TM1) and (TM2) are released and (TM4) operates. In 40 to 60 seconds, (TM1) and (TM2) are operated again, and (TM3) releases. In 60 to 80 seconds, (TM1) and (TM2) release for the second time, but (TM4) is locked to the timing ground lead. At this point, then, (TM2) and (TM3) are released, and (TM4) is operated, which provides a path for the operation of (REG) which operates (TN). The (TN) relay causes reorder signal to be sent to the originating end, as previously described. (REG) operates the stuck sender register through front contact of (ST2).

If disconnection of the originating end does not take place, the timing continues, and 20 seconds after (TN) operates the (TM1) and (TM2) relays are both operated again, which causes (LR2) to operate. This results in the operation of (AV) and disconnection of the sender.

AUTOMATIC PRIMING OF STUCK SENDER CANCELLED

If it is desired to cancel the automatic priming feature for stuck sender conditions, in order to trace trouble, the cancel priming key is operated at the make busy frame. Operation of this key transfers the lead which normally operates (AV) from front contact of (STS) back contact of (CP) and front contact of (ST2) to the winding of (CP). If registration is completed, as indicated by the operation of (ST2), then when the sender reaches the stuck sender position (STS) operates in turn operating (CP). (CP) operated, locks under control of the cancel priming key, opens the "S" lead to the link thereby breaking down the connections between it and the sender. The sender is held and the stuck sender lamp is lighted. If a stuck sender condition is reached but all digits have not been dialed then (AV) operates through a back contact of (ST2) and the sender releases just as though the cancel priming key had not been operated.

TIMING OF REORDER FLASHES WITH (OE) OR (RO) OPERATED

The operation of either (OE) or (RO) connects resistance battery to the (FL) interrupter. The first closure of the interrupter on its B contact operates (PU1), followed by operation of (PU2) when the interrupter closes its F contact. Subsequent closures of the B contact operate (RV2) which releases (RV1). When (RV2) releases, (RV1) reoperates to ground supplied by a front contact of (OE) or (RO).

The ground path for the operation of (RV2) is taken from the front contact of (L) to stop the flashing when the (L) relay releases on disconnection at the originating end. If the reversals were not stopped it is possible for the repeated momentary operation of the (L) relay to the cable capacity of the trunk to continue to hold slow-release relay (SR) operated, thus preventing disconnection of the sender.

Unless the originating end disconnects, the timing circuit operates in accordance with the conditions described in the preceding sections, to release the sender by operation of (LR2), the (STS), and if this fails, to light the (SS) lamp, finally.

M. F. SUPPLY

M. F. SUPPLY

MULTI-FREQUENCY SUPPLY

SD-95391

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MULTI-FREQUENCY SUPPLY (SD-95391)

PURPOSE

This circuit generates the six frequencies, 700, 900, 1100, 1300, 1500, and 1700 cycles used for **mf** key pulsing from switchboards and testboards and for multi-frequency outpulsing from senders.

GENERAL DESCRIPTION

Mf key pulsing uses 6 separate frequencies 700, 900, 1100, 1300, 1500, and 1700 cycles. These are used, two at a time, for the various digits and for the KP (setup) and ST (end of keying) signal. These six frequencies are generated by a group of 6 separate oscillators. Two groups of oscillators are provided for each supply equipment. The first group normally supplies current to the odd numbered switchboard positions and sender frames and the second group supplies the even numbered switchboard positions and sender frames. Transfer relays are provided so that the odd numbered positions and sender frames can be transferred to the second oscillator group of the even numbered positions and sender frames transferred to the first oscillator group. The installation is engineered so that each oscillator group is capable of carrying the entire load without serious drop in the output voltage.

To guard against failure in the output, sensitive voltage relays are connected across the output circuits of the oscillators in pairs in differential relation. Therefore, if the output voltage of one individual oscillator departs more than about 1.5 db from the output of its mate, the voltage relay operates and causes the load to be transferred automatically to the other oscillator group, and gives an alarm. Alarms are also provided as explained later for other unusual conditions.

THEORY OF A SIMPLE VACUUM TUBE OSCILLATOR

The fundamental circuit in Fig. 1 shows a simple vacuum tube oscillator. The theoretical functioning of this circuit is as follows:

The moment the filament switch is closed and the plate current is applied, the filament emits electrons which bombard the plate. A plate current will then flow from F to P through coil L_1 back to the negative terminal of the filament completing the circuit and resulting in a steady flow of current in the plate circuit.

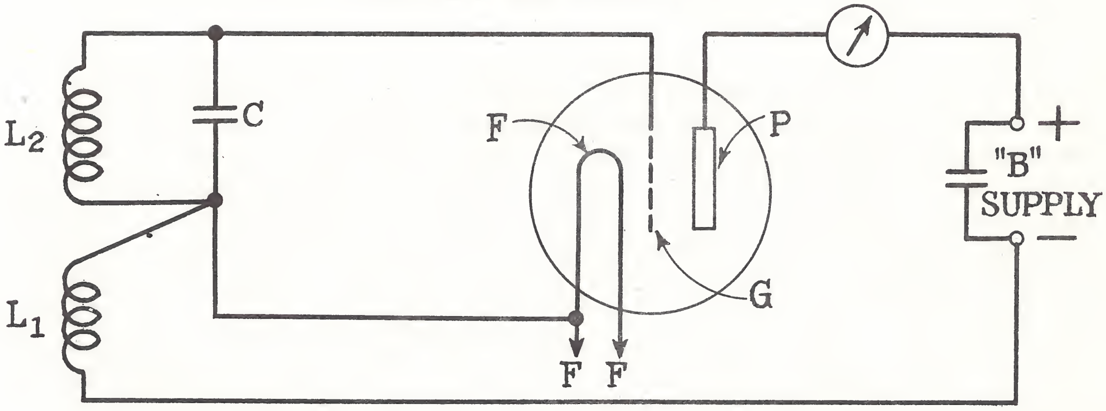
This would indicate that a magnetic field must be present about coil L_1. The field would appear to be steady because the flow of the plate current is assumed to be constant. The moment the switch was closed, however, the magnetic field about the coil L_1 expanded, which according to the electromagnetic law, would cut the coil L_2 in a given direction owing to its inductive relation and would consequently, induce an E.M.F. or difference of potential of a given polarity across it. If then the coils are wound in a direction in which L_2

would receive a positive potential at the top and a negative potential at the bottom, the grid which is connected to the top of the coil would receive a positive charge. This partly neutralizes the space charge between F and P immediately and allows more current to flow in the plate circuit PL_1F. This results in a greater expansion and movement of the field in the same direction about L_1 and consequently a greater E.M.F. of the same polarity is induced into L_2 resulting in a greater charge upon the grid. Again the plate current increases, and a heavier charge will again be placed upon the grid. This action will continue up to a certain point, depending upon the characteristics of the tube and the resistance of the circuit.

As soon as the plate current ceases to increase, the field around L_1 collapses and in so doing cuts L_2 in the opposite direction inducing an E.M.F. in L_2 of a reversed polarity. Thus, as the increase of the field around L_1 and L_2 made the grid positive, a decrease in the plate current will result in making the grid negative. Thus, if the positive charge on the grid increases the plate current, it is quite apparent that a negatively charged grid will decrease this current. The plate current will, when the grid is negative, decrease to a point below normal, just as it will increase above normal when the grid is positive. Hence, the plate current will decrease to a point at which there will be no further change in the grid potential. The complete cycle will then be reversed, and the operation will be completed all over again. Thus the plate current will rise and fall with a definite frequency, the period of which depends upon the values of the inductance and the capacity L_2C in the circuit. By using the proper constants, a circuit of this type can be arranged to produce frequencies ranging from the lowest audible range to the highest range in radio frequencies.

FIGURE 1

SIMPLE VACUUM TUBE
OSCILLATOR CIRCUIT



THEORY OF OSCILLATOR ON SD-95391 OS-79, 79-1

Applying the preceding explanation we see in the multi-frequency oscillator circuit OS-79 which is taken from SD-95391 that the plate current flows through the 5 and 6 winding of the out-transformer inducing an equal and opposite voltage in the 7 and 8 winding. This induced voltage is applied through the resistance to point 6 at A. The voltage at 5 of the out-transformer is applied through the resonant circuit (L induction coil and A condenser) to point 6 at A also. The resultant voltage at point 6A is impressed on the grid similiar to that which was impressed on the grid G in Fig. 1.

Since the impedance of the resonant circuit is slightly higher than the resistance, it is possible to vary the resultant voltage at A by applying the varistor to the various taps of the L coil. The varistor is connected to the tap which gives the required output power.

The circuit functions the same as the preceding explanation and the current in the high winding of the out-transformer (5-6-7-8) is induced into the low winding, shown on OS-79 and put out on the line.

The frequency is determined by the L induction coil measured in henry's (h) and the capacity of the A condenser measured in microfarads (mf).

TESTING AND ADJUSTING OUTPUT VOLTAGE OF INDIVIDUAL OSCILLATORS

The output voltage of the oscillators is effected somewhat by temperature changes in two classes of apparatus in the circuit. In the first class are coils and condensers which readjust themselves slowly to changes in ambient temperature. Accordingly, the oscillators should be in the ambient temperature of the testing location for a period of approximately 12 hours immediately prior to the tests. In the second class are varistors, together with certain resistances and the vacuum tubes which assume steady state temperatures in a shorter time as a result of normal operating currents in the oscillator circuits. In order to insure this steady state temperature the oscillators should be in an operating condition for at least two hours immediately prior to the tests.

Measurements of output voltage may be made by means of a 40B transmission measuring set or its equivalent arranged to measure "level" or by means of a 600-ohm transmission measuring set. When a high impedance measuring set is used, it should be connected to the single frequency output jack (700 cycles)-(1700 cycles) of the oscillator under test, by means of patching cords, making use of a patching trunk to the multi-frequency test bay if necessary. Condition the set for reading a level of approximately +18 dbm. Under this condition, connect lead "X" to tap 1-5 on coil (L-) to adjust the output to +17.8 db as closely as possible. These taps are designed to vary the output voltage in steps of 0.5 db. Accordingly, it should be possible to adjust to a reading on the transmission measuring set of minimum +17.55 db and maximum 18.05 dbm. Ordinarily it should be possible on new apparatus to make the proper adjustments by using taps 2 to 5 leaving tap 1 to compensate for aging of the varistor units after a considerable period of use.

In making these tests no allowance need be made for plate or filament battery variations normally encountered in an office.

In case an oscillator can not be made to meet the output level requirements by adjusting the taps on coil (L-) the most probable causes of failure are the vacuum tube and the varistor unit.

If a check on a vacuum tube test set indicates that the tube is in proper condition, and if no other cause for trouble is apparent, the varistor unit, including the resistance which is included should be replaced. A defective tube will usually be indicated by a low output voltage, while a defective or open-circuited varistor will usually be indicated by a high output voltage. Defects in the tuning inductance (L-) and condenser (A-) will usually cause a change in output frequency as well as amplitude.

Where a 40B set or other high impedance measuring device is not available, a 600-ohm transmission measuring set may be used with the voltage and alarm test jacks. The single frequency output jacks of the oscillator under test are patched to the (OSC) jacks and measurements made with the 600-ohm transmission measuring set at the (MEAS 600^{W}) jacks. With the correct output as described above the set should measure 0 dbm and the output should be adjusted to within ± .25 db of this value as described above.

TRANSFER AND ALARM FEATURE

Alarms are provided to give audible and visual signals in case of trouble and for certain types of troubles, the load on the oscillator group in trouble is transferred automatically to the other oscillator group. Troubles which may bring in an alarm without automatic transfer are:

A. Operation of a fuse or a discontinuity in the wiring associated with the transfer relays.

B. A ground of about 3300 ohms or less on the output leads to the switchboard positions, senders, or testing circuits.

C. Operation of a manual transfer key (SWO) or (SWE) associated with the odd or even oscillator group at a time when the other group is already in a transferred condition.

D. Trouble ground on one of leads to senders which indicates supply circuit transfer.

Troubles which bring in an alarm and at the same time transfer the load are:

A. An increase or decrease in the output voltage of a single oscillator beyond the prescribed limits.

B. Failure of all oscillators in a group due to loss in plate voltage.

C. Failure of a heater circuit of any one pair of oscillator tubes.

If a high or low voltage output is due to a trouble on the load side of the transfer relays, the transfer of the load to the other oscillator group is cancelled and a visual indication given to denote this condition.

OPERATION OF TRANSFER CIRCUIT

AUTOMATIC TRANSFER

Any trouble which causes a change in the output voltage of one of the oscillators in the odd oscillator group of sufficient magnitude to operate voltage relay, connects ground to lead HL1. A similar trouble in the even oscillator group connects a ground to lead HL2. Assuming a trouble in the odd group, the ground on lead HL1 lights lamp (VO) and operates relay (A1). Relay (A1) operated (1) starts the release of slow release relay (C1), and (2) operates relay (B1) over lead (K1). Relay (B1) connects ground over the G1 to G6 leads to the senders to stop outgoing a-c pulsing while the transfer is being made. When slow release relay (C1) finally releases relay (D1) operates and ground over lead (H1) operates relay (TO). Relay (TO) operated, (1) short-circuits resistances (OA) and (OB) and the windings of relay (BO), thereby operating relays (TO1), (TO2), (TO3) and (TO4), (2) closes a ground for the operation of relay (ALM) through its primary winding. Relays (TO1), (TO2) and (TO3) transfer the odd numbered positions and sender frames to the even oscillator group and relay (TO4) lights lamp (TO) to indicate the transfer and opens the operating path of relay (B1). This releases relay (B1) to permit outpulsing from the senders to proceed. Relay (ALM) operates the major alarm but the alarm may be silenced by the (SWO) key. Lamp (SWO) is a guard lamp to indicate the off-normal position of the (SWO) key. Key (SWO) holds relay (A1) (or relay (TO)) operated.

When the trouble in the odd oscillator group has been cleared, the contact of the voltage relay or relays which may be closed are restored by the knob on the front of the relay removing the ground from lead HL1. Key (SWO), if operated, is restored and relay (A1) (or relay (TO)) releases. Release of (A1) (1) connects ground over lead J1 and the contact if relay (TO4) operated, to reoperate relay (B1) and again stop outgoing pulsing from the senders, (2) operates relay (C1) and (3) releases slow release relay (D1). When (C1) operates and (D1) releases ground is removed from lead "H1" releasing relay (TO). This removes the short circuit from resistances (OA) and (OB) and the windings of relay (BO). The additional resistance introduced releases relays (TO1),(TO2), (TO3) and (TO4) thus transferring the odd positions and sender frames back to the odd oscillator group. Relay (TO4) released, releases relay (B1) to permit outpulsing from the senders to proceed.

If a trouble appears in one of the oscillators in the even oscillator group, ground is connected to lead HL2. Relays (A2), (B2), (C2) and (D2) then function as described above and result in the operation of relays (TE),(TE1), (TE2), (TE3) and (TE4), to transfer the even numbered positions and senders to the odd oscillator group and to sound the alarm. The alarm may be silenced by the (SWE) key. When the ground is removed from lead HL2 by restoring the contact of the voltage relay which is closed and key (SWE) is restored to normal the even numbered positions and sender frames will be transferred back to the even oscillator group as described above.

MANUAL TRANSFER

Operation of the (SWO) key operates relay (A1), or relay (TO). Operation of relay (A1) or (TO) causes the odd numbered positions and sender frames to be transferred to the even oscillator group as described above but prevents the operation of the alarm. Similarly the (SWE) key may be used to transfer the even numbered positions or senders to the odd oscillator group. Momentary operation of the alarm when making a manual transfer may be prevented by operating the (B ALM) key.

CANCELLATION OF AUTOMATIC TRANSFER

If a voltage change occurs in the odd oscillator group of sufficient magnitude to ground lead HL1 and cause an automatic transfer and if the trouble is on the load side of the contacts of the transfer relays, the transfer will take place as described above operating relays (TO1), (TO2), (TO3) and (TO4).

Immediately however, one or more of the relays associated with the even numbered positions and senders will operate because of the trouble being transferred with the load. Ground is then connected to lead HL2 and, with relay (TO4) operated, operates relay (LO) which locks under the control of the (CO RLS) key. Relay (LO) lights the lamp (LO) to indicate this condition and operates relay (CO). Relay (CO) opens the ground being supplied over lead HL1 and releases relay (A1) or (TO) which transfers the odd positions and senders and the trouble back to the odd oscillator group. Relay (CO) holds relay (ALM) to maintain the audible alarm since it would otherwise be silenced by the release of relay (TO). When relay (CO) is operated the alarm may be silenced by the (CO ALM) key which in the operated position lights the guard lamp (CO ALM) to call attention to the off-normal position of the key.

If a trouble occurs on the load side of relay (TE1), (TE2) or (TE3) associated with the even positions and sender frames ground will be connected to lead HL1 in the manner described above immediately after the transfer is completed. Relay (TE4) being operated, this operates relay (LE) which locks under the control of key (CO RLS), lights lamp (LE) and operates relay (CO) to cancel the transfer.

If the (SWO) key has been operated to affect a manual transfer and a trouble appears on the even oscillator group, ground will appear on both leads HL1 and HL2 since both are in parallel. Ground on lead HL1 will be ineffective since relays (A1) or (TO) are being held by key (SWO). Relay (TO4) being operated, ground on lead HL2 will operate relays (LO) and (CO) in turn thereby operating the alarm. Similarly a ground on lead HL1 when key (SWE) is operated will operate relays (LE) and (CO) in turn and operate the alarm. In either case the manual transfer will remain in affect until the (SWE) or (SWO) key is restored and relays (LO) or (LE) and (CO) will remain operated until released by the (CO RLS) key.

If the (SWO) key is operated while the even numbered positions and senders are transferred or if the (SWE) key is operated while the odd positions and senders are transferred the alarm sounds to indicate improper key operation.

BATTERY ALARM IN TRANSFER CIRCUIT

Relays (TO1) and (TO2) and (TO3) and (TO4) are normally energized in series with resistances (OA) and (OB), respectively, and the high resitance windings of relay (BO). The windings of relay (BO) are opposing so that none of the relays operate. If battery A fails or the continuity through relays (TO1), (TO2), resistance (OA) and the primary winding of relay (BO) is otherwise interrupted, relay (BO) operates on its secondary winding. If battery B fails or the continuity through the secondary winding of relay (BO) is otherwise interrupted, relay (BO) operates on its primary winding. Operation of relay (BO) lights the (B OFF) lamp and operates relay (ALM) to give an alarm. The alarm may be silenced while the trouble is being cleared by means of the (B ALM) key. The guard lamp (B ALM) lights to indicate the off-normal position of the (B ALM) key.

If battery A fails while relay (TO) is operated, relay (TO) and the transfer relays (TO1), (TO2), (TO3) and (TO4) will release. As soon as relay (TO) releases, relay (BO) will operate to give the alarm.

If battery B fails while relay (TO) is operated, relay (BO) cannot operate because its primary winding is short circuited. When relay (TO4) releases, its back contact connects a ground through the contact of relay (TO), operated, to give the alarm.

Similarly, failure of either battery C or battery D associated with relays TE, TE1, TE2, TE3 and TE4 will cause operation of relay (BE) to bring in an alarm.

GROUND ALARM ON OUTPUT LEADS

Battery is connected through relay (GO) to the midpoints of output transformers in the odd oscillator group or through relay (GE) to the output coils in the even oscillator group. Ground on any of the associated output conductors through a resistance of not more than approximately 3300 ohms causes the operation of relay (GO) or (GE). The operation of either relay lights lamp (G ALM) and connects ground over lead "G" to operate the (ALM) relay which in turn sounds the major alarm. The alarm may be silenced by the operation of the (G ALM) key which also lights the (G ALM) lamp and connects a buzzer to the contacts of relays (GO) and (GE). The buzzer will operate as long as the ground is present but may be silenced by the (BUZ) key.

GROUND ALARM ON TRANSFER LEADS TO SENDERS

In case of a trouble ground on any lead G1 to G6 or TR lead, the associated E or F relay will be operated to battery on one of the contacts of keys 1-4, 2-5 or 3-6. Operation of this E or F relay will open the operating circuit of normally operated relay AL which releases, in turn operating relay ALM to operate the audible alarm circuit. At the same time, the operation of the E or F relay lights the associated lamp to indicate to the attendant that the ground is on one of the three leads associated with that relay. The attendant may then determine the particular lead in trouble by operating keys 1-4, 2-5 and 3-6 one at a time. The key operation which extinguishes the lamp is the number of the lead which is grounded, i.e., if key 2-5 operation extinguishes lamp E456 the lead in trouble is the even No. 5 lead.

PLATE AND FILAMENT BATTERY ALARM

The total space current for the six oscillator tubes is sufficient to maintain relay (PL) in an operated condition but is insufficient to operate relay (PL1). Failure of the plate battery supply, either 130 volts or 48 volts, causes the release of relay (PL) which connects ground to lead "P1" or "P2" and over lead "HL1" or "HL2" to operate the alarm and transfer circuit. In case condenser (F1) or (F2) becomes short-circuited the "B" battery supply to the oscillators would fail but relay (PL) would not release. Under this condition, however, relay (PL1) operates on the short circuit current through the condenser and through lamp (P) and retard coil (PL), together with relays (PL) and (PL1) which current amounts to approximately .150 ampere. The operation of relay (PL1) also connects ground to lead "P1" or "P2" causing the operation of the alarm and transfer circuit.

OSCILLATOR VOLTAGE ALARM

The output of each oscillator is connected to the voltage alarm circuit the connection being made on the load side of the transfer relays. Each frequency is connected to one of the rectifier elements in a double rectifier unit. The output of the two elements in each unit is connected across resistances in opposing directions to a meter type relay having a zero center adjustment with no current flowing. As long as the voltage from both oscillators in a pair is equal no current flows in the relay. The normal variation in output voltage in any oscillator is approximately ± .5 db neglecting variations due to temperature changes inasmuch as the temperature changes affect all oscillators in a group in the same manner. Accordingly, one oscillator output may be .5 db above normal and the other .5 db below normal. For this reason the relays in conjunction with the rectifier and resistance units are designed to non-operate on a difference of 1 db between the two oscillator outputs. The relays will operate on an additional variation of .5 db up or down from either oscillator. The exact variation in the oscillator voltages to cause an alarm is subject to some adjustment by moving the contacts of the relay farther apart or closer together. They should be adjusted as close as possible without causing unnecessary alarms. Most probable cases of trouble in an oscillator should reduce its output. However, if the circuit associated with the varistor (VR-) in the oscillator circuit should be opened or if the varistor should change to a higher resistance value, the output voltage would increase. For this reason, the alarm circuit is designed to operate at high as well as on low voltage variations. The alarm circuit will not function if the output voltage of two paired oscillators increases or decreases together. Simultaneous increases are not probable except in the case of uniform aging of two (VR-) varistors.

This would occur at a slow enough rate to permit the output variations to be discovered on periodic routine tests on the oscillators before the increase in voltage became objectionable. The two probable causes of simultaneous decrease in the output voltage of the two oscillators are failure of the plate battery or of the heater circuit of the two tubes involved. The first of these cases is covered by the functioning of the (PL) relay. Failure of a heater circuit would cause the operation of two voltage relays because of the fact that the pairing of the oscillator tube heaters is different from the pairing of the oscillator outputs in the relay circuit. Operation of a relay to the "high" or "low" side connects ground to lead "HL1" or "HL2". This ground caused the output leads from the oscillator group in trouble to be switched to the other oscillator group and also sounds the major alarm.

The contacts of the relays are provided with small permanent magnets so that when a contact closes it remains closed until reset manually. Resetting is accomplished by using one of the small metal knobs on the face of the relay to back the contact away from the arm far enough to permit the arm to restore to its normal zero center position.

CHECK OF VOLTAGE ALARM

The operation of the voltage alarm may be checked by means of the voltage and alarm test circuit. The output of the one oscillator of a pair is patched to the (OSC) jacks and its output measured and noted. This measurement may be made at the (HIGH IMP) jacks with a 40B set or its equivalent or at the (600^{W}) jacks by means of a 600-ohm transmission measuring set. The mate oscillator of the pair in the voltage alarm circuit is then patched to the (OSC) jacks. The (CO ALM) key is operated to prevent operation of the major alarm, the (ADJ) potentiometer is turned counterclockwise against its stop and then the non-locking (ALM TEST) key is depressed. The (ALM TEST) operated relay (CO) to prevent an automatic transfer when the voltage relay operates and closes a shunt consisting of resistance (L) and potentiometer (ADJ) across the output of the oscillator under test which causes a drop in the output voltage. The resistance in the (ADJ) potentiometer is gradually decreased until the oscillator output voltage drops to the point where the voltage relay operates as indicated by the lighting of the (VO) or (VE) lamp, and the output level noted. The difference between the output of the first oscillator and its mate in these tests indicates the sensitivity of the associated voltage relay. After each operation of a voltage relay, the (ALM TEST) key should be released and the relay contact reset by the knob on the front of the relay.

By interchanging the first oscillator and its mate in the above tests, the same voltage relay can be tested for operation in the opposite direction. These tests may be repeated for each of the 6 pairs of oscillators (3 even and 3 odd pairs) and their associated voltage relays.

FREQUENCY TESTS

The frequency test circuit is provided for make comparison tests between the output of a single frequency oscillator in one group and the oscillator of the same frequency in the other group. Comparison tests can also be made between the single frequency output of any one oscillator and an external variable frequency oscillator supplying approximately the same voltage. The output of the two oscillators to be compared are patched into jacks (OSC1) and (OSC2) while a head receiver is connected to jacks (REC). The network of resistances is designed to provide a satisfactory level for making audible comparisons by means of the receiver. The resistance values are high enough to prevent mixing the output of one oscillator with the other to a degree which will interfere with signaling on either oscillator which may be in service. In setting up the patch cords for tests described in this paragraph, plug into the frequency test jacks first, to prevent accidental shorts or grounds on working oscillator outputs through the plugs on the free end of cords.

BUZZER CIRCUIT

The buzzer (BZ), is provided to facilitate locating trouble in case of an alarm. In case of a ground on output pairs, a major alarm is sounded and may be silenced by operation of the (G ALM) key. Operation of the key connects the buzzer to the contacts of the alarm relays (GO) and (GE) so that while the major alarm is silent buzzer (BZ) continues to sound as long as the alarm relay remains operated. Most troubles in distribution wiring will be isolated by opening straps to isolate the various groups of output wiring at a terminal strip. As soon as the group or conductor in trouble is isolated by means of these straps, relay (GO) or (GE) will release, silencing the buzzer. Operation of the (BZ) key prevents the buzzer from functioning.

DISTRIBUTING RESISTANCES

To prevent individual circuit troubles from affecting the supply, distributing resistances are provided at the supply equipment in each of the leads to the switchboard keyset and sender circuits. A group of resistances are carried to the positions or sender frames in a separate cable and distributed to the positions served or to the sender frames.

For switchboard positions having mf and d-c key pulsing switching relay circuits, the paired supply leads from the distributing resistances are cabled directly to the switching relays. From the relay location to the switchboard position, paired conductors are used for each frequency, one conductor of each pair being unused. This provides a marked reduction in the distributing effect of these distributing leads in the idle (non-signaling) condition.

For test circuits a separate cable is used to each test circuit location with distributing resistances to secure proper pairing up to the location of the test equipment. The unused leads are terminated at the test equipment.

DISTRIBUTING JACKS

The distributing jacks are connected directly across the output supply leads from the transfer and alarm circuit. Two sets of jacks are provided, one set for the leads supplying even numbered positions and senders and the other set for the leads supplying odd numbered positions or senders. In case of severe damage to the apparatus or wiring of the alarm and transfer circuit, the (EVEN) or (ODD) 700-cycle to 1700-cycle jacks may be patched to the corresponding 700-cycle to 1700-cycle jacks of the associated oscillator group unit. The intervening wiring may then be disconnected at the terminal strips on the oscillator group unit and transfer and alarm unit and the load supplied directly over the patching cords while the damage is being repaired.

WHEN USED FOR TESTING SUPPLY ONLY

When the circuit is used as a supply for testing purposes only, the following figures on the print No. SD-95391 are furnished: One Fig. 1, through Fig. 5 or 6, on each Figs. 17 and 18, as many Figs. 12 as there are test circuits, and as many Figs. 13 as are required.

EXPLANATION OF TERMS USED IN OSCILLATOR CIRCUITS

POTENTIOMETERS

A potentiometer is a variable resistance.

VARISTORS

A varistor is a rectifying device for changing a-c to d-c. A varistor unit acts as a half wave rectifier similiar to the action of a diode tube.

There are copper oxide, selenium, and germanium.

A. A copper oxide varistor is small in size and consists of small copper discs coated on one side with a layer of copper oxide, and bolted together to cause pressure between the copper and the oxide. Such a unit offers very low resistance to current in the direction of from the oxide to the copper, but very high resistance in the opposite direction from the copper to the copper oxide. These varistors are used for rectifying small voltages.

B. Selenium varistors function in a similiar manner but are larger and used as the power supply rectifier for converting the 60 cycles a-c to d-c for tube plates, screens and relays.

C. The germanium varistor is very small and functions like the other varistors but is more on the principle of a fixed crystal such as the old "crystal detectors" that had to be adjusted with a "cat whisker." These varistors are used as detectors.

THE "DB" (DECIBEL)

The "db" is the unit for measurement of transmission losses and gains.

Standard testing power for transmission measuring is "0" db, which represents a power of one milliwatt sent into a 600-ohm line or circuit.

The loss of a circuit or the gain of an amplifier is usually measured by sending a 1000-cycle tone (from an oscillator) into one end and measuring the strength of the tone received at the other end, with a transmission measuring set.

RETARD COILS OR CHOKES

These coils function to retard or choke back unwanted a-c signals but permit d-c or wanted lower frequency a-c signals to pass through.

FILTERS

Band pass filters or networks (usually a coil and condenser arrangement) so tuned or adjusted as to allow only a certain wanted band of frequencies to pass through.

MARKER CONN.

MARKER CONN.

TANDEM MARKER CONNECTOR SD-25488

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TANDEM MARKER CONNECTOR CIRCUIT

SD-25488-01

PURPOSE OF CIRCUIT

The tandem marker connector circuit is used in conjunction with tandem senders for the purpose of connecting these senders to tandem markers.

DESCRIPTION OF EQUIPMENT

There are three connector circuits per connector frame, numbered 0 to 2 from the bottom up. The numbering of the connector frames, also, starts at zero.

Each marker connector is arranged to serve a maximum of five tandem senders. No sender appears in more than one connector. The markers, however, are multipled throughout all the connectors, so that any sender may be connected to any marker. The circuits are so arranged that only one sender multi-contact relay or pair of relays and one marker multi-contact relay or pair of relays in a particular connector can be operated at one time, and only one marker multi-contact relay or pair of relays belonging to a particular marker can be operated at one time.

The connector circuits of an office are divided into as many blocks as there are marker circuits, each block taking a different one of the markers as first choice. If that one is busy, the nearest idle one is selected, the markers being arranged in a definite order in a chain circuit.

CIRCUIT NOTES

OPERATION OF SENDER MULTI-CONTACT RELAYS OS-80-1

SP

When the tandem sender has registered the office brush and office group selections, it operates the DST relay, which connects battery to the ST and CBS leads for calling in the marker connector. The connection of battery to the ST lead causes the preference relay SP to operate in series with the CA1 relay of the alarm circuit. Assuming that no other sender is calling in the same connector, the associated SCA and SCB relays operate.

Relays SP, SCA, and SCB are provided in the connector for each sender. These relays are wired per figure A for the first sender, figure B for intermediate senders, and figure C for the last sender. The operating path for the SP relay is traced through normal contacts of preceding SP relays (except for the first one) or through its own normally closed make before break contact and operated contacts of a succeeding SP relay (except for the last one.) This is to prevent its operation if a preceding SP relay is operated and all succeeding SP relays are normal, and is a factor in causing waiting senders to be served in rotation from the last to the first. The SP relay for the first sender can operate at any time, independently of the other relays in the chain.

The SP relay locks, except for the first sender, and the CA1 relay holds in series. The CA1 relay connects ground to the CA1 interrupter to start the timing circuit as described later for giving an alarm if the connector circuit should fail to operate a marker multi-contact relay.

OS-80-1
SCA
SCB

Connection of battery to the CBS lead is the battery supply for the associated SCA and SCB relays and serves to allow only those senders originating calls to have battery connected to their SCA relays, thereby reducing the possibility of operating SCA relays falsely.

In order for the SCA relay to operate, all succeeding SP relays must be normal as the ground is furnished at the last one through a normal contact chain. This circuit arrangement prevents interference in case of simultaneous calls from senders, causing two or more SP relays to operate and together with the SP relay operating paths described above, insures that the senders are served in rotation from the last to the first.

Operation of the SCA and SCB relays closes the receiving, control and release leads from the sender to the common wiring on the marker relays MCA and MCB so that the operation of one pair of these relays, described below, will connect the leads to a marker.

MARKER PREFERENCE

OS-80-2
MP

Relays MP are provided in each connector for each marker to which the connector has access. These relays are wired per figure D for the first marker, figure E for intermediate markers and figure F for the last one.

In order to reduce the number of simultaneous calls for a particular marker and to distribute the calls as evenly as possible, different connectors are given different markers as first choice.

This is accomplished by dividing the connectors of the office, in as nearly equal parts as possible, into as many blocks as there are markers, and cross-connecting the A punchings at the GT relay as follows. In the connectors of the first block, the A punching of figure 2 is cross-connected to the B punching of figure D, this figure being associated with the first marker. In the connectors of the second block, the A punching is cross-connected to the B punching of the first figure E, which is associated with the second marker. The remaining connectors are wired in a similar manner, those of the last block having their A punchings connected to the B punchings of figure F. This is illustrated in OS-80-2 which gives the cross-connections required in an office having four connectors and three markers.

In addition, as shown in OS-80-2 preference chains are provided for each marker throughout all the connectors. With respect to the connector equipment for the first decoder, the D punching of each connector of the office is cross-connected to the E punching of the preceding connector, except for the first connector of each block which has its D punching connected to ground. This provides a normal contact chain for the operation of MP relays, permitting any MP relay to operate if all preceding MP relays are normal, and preventing the operation of an MP relay if any preceding one is already operated. The E punching of the last connector (for the first marker) is connected to the DA punching, providing a path for the normally operated DA-1 relay in the marker, described later, with all the MP relays for that marker normal. There is a marker control circuit for each marker, for use with the connector equipment for that marker throughout all connectors.

A similar chain circuit in the opposite direction is provided for operating MC relays, by connecting the H punching of each connector to the G punching of the following connector, except for the H punching of the last connector, which is wired to ground. With this circuit arrangement, in case of simultaneous operation of MP relays, only the MC relay in the higher numbered connector can operate, this circuit having the preference for the first marker. The G punching of the first connector is connected to the F punching, providing a path for the normally operated DA-2 relay in the marker, with all MP relays normal.

In a similar manner chain circuits as described above are provided for the second marker throughout all connectors, except that the start and end points are changed. The D and G punchings of the first connector of the second block are connected,respectively, to ground and the F punching. The E and H punchings of the first connector are wired to the D and G punchings of succeeding connectors, respectively. The E and H punchings of the last connector are wired to the DA punching and ground, respectively.

With the cross-connections given above, it is evident that the chain circuits for the second marker start at the first connector of the block having that marker as first choice, and end at the last connector of the block having it as last choice, the connectors being considered to be wired in a circle.

In a similar manner, the chain circuits for the third marker start as the first connector of the third block and end at the last connector of the second block.

In offices having more than three markers, and consequently more than three block divisions, additional chain circuits are provided as described above, starting for each marker at the first connector of the block having that marker as first choice and ending at the last connector of the preceding block.

The MP relay to operate is the one for the marker that is first choice in the calling connector, if that circuit is idle, which is the assumed condition. The path to operate the MP relay is traced from battery on the ST lead from the sender, operated contacts of the SCB relay, normal contacts of the GT relay, A punching, cross-connected as previously described to a B punching, normal contacts of the CB relay, winding of the MP relay, and over the D-E chain to ground at the first connector of the block.

OS-80-2

F & DA LEADS

As previously described, there is a decoder control circuit per figure 6 for each marker. The DA-1 and DA-2 relays are operated in the marker while the marker is idle, over the D-E and G-H chains. They release due to operation of the MP relay associated with the marker in any connector. Release of these relays starts the marker timing circuit, described later, by connecting ground to the TM lead.

OS-80-2

MC

The path to operate the MCB relay is traced over the G-H chain to ground at the last connector of the block having the marker as second choice. This circuit arrangement prevents interference in case of simultaneous calls in different connectors for the same marker, operating two or more MP relays. Ground at operated MCB relay operates MCA relay.

Operation of the MCA and MCB relays closes the receiving, transmitting and control leads through the connector and consequently from the tandem sender to the associated tandem marker. Ground is connected to the CKG lead to the marker from the connector SCA relay and additional ground is connected to the TM lead from the MCB relay.

The operating battery for the associated connector CB relay is short-circuited when the MCB relay operates. The MCA relay connects a holding ground to the GRA relay.

When a marker calls in the trouble indicator, it grounds leads FRG, CNG and SNG to the connector. These grounds are extended to the trouble indicator over leads FR, CN and SN to record the numbers of the connector frame of the connector on that frame and of the sender in that connector.

When the sender test circuit tests a sender it grounds lead SDT associated with that particular sender. Then when the connector seizes a marker, this lead is extended to the marker as an indication that this is a sender test call.

OS-80-2

CBR, CBS & CBT

Relays CBR, CBS and CBT are provided for each marker as required so that the marker can hold itself busy at all connectors. These two relays provide a sufficient number of leads for an office having thirty-four connectors.

OS-80-2

CB

Connector circuit CB relays in all connectors associated with the selected marker operate, except the one in the connector which has seized the marker. These relays operate over individual CB leads grounded by the operated CBR and CBS relays. The CB relay in the connector which has seized the marker does not operate as it is short-circuited by the MCB relay operated.

The operated CB relays open the paths to their associated MP relays and close them in each case to the CB and MP relays associated with the next choice marker. If any other MP relays associated with the same marker were operated, due to simultaneous calls for the marker, they release at this time.

Due to the CB relays operated, subsequent calls in connectors having the busy marker as first choice will cause an MP relay for the second choice marker to operate, if that circuit is idle. In a similar manner, any marker upon being seized and operating its CB relays in the connectors causes calls that would otherwise be routed to them to make an initial attempt on the next choice circuit or the nearest idle circuit. The CB relays for the last marker extend the start leads to the equipment for the first marker. Operated CB relays in busy connectors lock, except those in connectors in which all of the CB relays are operated.

The operated CB relays lock to prevent a connector which has started to seize a second or later choice marker from abandoning that choice and reverting to an earlier choice circuit if one becomes idle at this time. The locking paths are not effective in connectors having all their CB relays operated, as this would cause interference with waiting calls not yet connected to markers.

The sender is now closed through to the marker and the marker is made busy in all other connectors as the paths to its MP relays in these connectors are open. The connector circuit holds the connection until the marker has received the information from the sender, returned the decoded information, and determined that there is an idle trunk to the called office. It then causes the sender to release the connector.

SIMULTANEOUS CALLS

The following examples are given to illustrate the action of the SP and MP relay chains with respect to simultaneous calls.

SIMULTANEOUS CALLS IN ONE CONNECTOR

As previously described, any SP relay can operate if all preceding SP relays are normal or if a succeeding SP relay is operated.

If any two or more senders, within one connector, connect battery to their start leads simultaneously with no other SP relays already operated, the two or more associated SP relays can operate. For example, if the first and last senders (number 0 and 4 in the connector) call at the same time, the SP relay for the #0 sender operates as in regular operation. While it is operating, the SP relay for the #4 sender can also operate, closing its locking path before its operating path is opened by the SP relay for the #0 sender. Any number of SP relays within one connector can operate simultaneously as above.

In this case both SP relays remain operated but the only SCA relay that can operate is the one for #4 sender. This sender thus has preference. When the #4 sender releases its SP relay, the SCA relay for the #0 sender operates and that call proceeds.

ADDITIONAL CALLS WITH SENDERS WAITING

In this case it is assumed that the SP relays for the #1 and #3 senders have operated simultaneously. The #3 sender in this case receives the preference. While the #3 sender is still engaged and the #1 sender is waiting, it is assumed that the #2 sender calls. The SP relay for the #2 sender operates through its own normal (make before break) contacts and through operated contacts of the SP relay for the #3 sender. The make before break springs permit the relay to operate through its own normal contacts and to lock.

With the SP relays for the #1, #2 and #3 senders operated, the SP relay for the #0 sender can still operate. The SP relay for #4 sender cannot operate under these conditions.

The senders associated with operated SP relays are served in order from the last to the first, each SP relay in releasing closing ground for the next preceding SCA relay. If any senders connect battery to their start leads while a call is being served in a lower numbered sender these senders operate their SP relays simultaneously after the sender with SP relay already operated has been served and its operated SP relay has released. The preference then continues as described above.

SIMULTANEOUS CALLS FOR ONE MARKER

As previously described, any MP relay for an idle marker can operate if the MP relays in all preceding connectors,up to the ground end of the D-E chain, are normal.

If two or more connectors in the same block (or temporarily included in the same block due to marker busy conditions) connect battery to their A punchings simultaneously with no other MP relays for the marker already operated, the two or more associated MP relays can operate and lock. For example, if the connectors #0 and #1 call at the same time, the MP relay for connector #0 operates and locks as in regular operation and the MP relay for connector #1 operates simultaneously, closing its locking path before its operating path is opened by the MP relay of connector #0. Any number of MP relays for one marker can operate simultaneously as above.

In this case the only MCB relay that can operate is the one for connector #1 and the MP relay of connector #0 releases when the CB relays operate, advancing the start leads.

MARKERS OTHER THAN FIRST CHOICE

When a marker becomes busy, operation of its CB relays causes all remaining idle connectors having it as first choice to be temporarily associated with their second choice marker. For example, a call in connector #0, connecting to the first marker causes connector #1 to be temporarily associated with the second marker, together with connector #2. Any of these connectors calling singly seizes the second marker. Simultaneous calls in these connectors operate their MP relays for the second marker and the preference starts at the connector nearest the ground end of the GH chain as before. Under these conditions, if the second marker becomes busy, all remaining idle connectors are associated with the third marker, the preference being determined as before. In a similar manner, the last marker extends the start leads to the equipment for the first one.

If two or more connectors call simultaneously and their choices fall on different idle markers, all connections are made at once. If their choices fall on the same marker, the preferred connector seizes it as described above. The unsuccessful connectors connect to succeeding idle markers without appreciable delay, if there are any available, due to the CB relays in operating advancing the start leads.

If the connectors call while all markers are busy, they are served as markers are freed, in regular order, depending upon the preference chains.

CONNECTOR TRAFFIC REGULATOR OS-80-1

In periods of heavy traffic when all markers are not in service, connectors may be delayed in seizing markers. In order to equalize these delays between the various connectors and prevent any connector from having extreme delays, a traffic regulating feature is provided. Otherwise some connector having comparatively slow operating MP relays might be delayed for many seconds while other connectors seized markers quickly.

The method used for regulating traffic is to lock out of service any connector which has seized a marker until all other waiting connectors have each served one call. This accomplished by gate relays GT and GT1.

When a call enters a marker and succeeds in operating an MC relay, the GT and GT1 relays associated with the connector operate. When the sender releases the connector, the MC relay releases and removes the operating ground for the GT relay. Now if some other connector is waiting for a marker to become idle, that connector and all others waiting have an SC relay operated, which provides a locking circuit for all connector GT relays operated. The number of GT relays operated would be equivalent to the number of markers in service.

The locking circuit for the GT relay is from battery on the "B" lead, break contacts of (CA6) winding of GT relay, make contacts GT1 and GT relays, common strap lead CP to all connectors which are waiting for markers, break contacts of their GT and GT1 relays, make contacts of SCB relay to ground.

As long as a GT relay remains operated, the path from the start lead to the A punching remains open, so that no connector will reseize a marker until all GT relays in waiting connectors have been operated, at which time all GT relays are unlocked. The GT relays in connectors which are not serving calls at the moment release, in turn releasing their GT1 relays. Now if any of these connectors has a new call waiting, it connects locking ground on the common strap lead CP thru the back contacts of the GT1 relay. Relay GT1 is therefore made a little slow release in order to permit all GT relays to release.

CONNECTOR TIME CIRCUIT
TIMING FOR CONNECTION OF MARKER

OS-80-1

The connector time alarm circuit provides an audible major alarm, indicates the sender and connector involved, if the connector circuit should fail to function properly within a certain period of time. In addition, if any traffic regulator trouble blocks the connector, the traffic regulator is incapacitated, allowing traffic to use the connector without using the traffic regulator.

The time measure starts when ground is connected to the CA1 interrupter by operation of the CA1 relay upon seizure of the connector. An additional ground is connected to the CA1 interrupter when the SC relay operates. This is to provide for alarm facilities if the CA1 relay should fail to operate or if the SC relay should fail to release.

The CA4 relay operates in from 5 to 12 seconds after the CA1 relay operates, depending upon the position of the interrupter when the connector is seized. Ordinarily the connector circuit is released, releasing the alarm relays, before the expiration of this period of time. However, if there are no markers available and the connector is delayed long enough to operate the CA4 relay, a major alarm is started by grounding the CT lead and the C lamp corresponding to the connector is lighted at the trouble indicator frame.

The CA4 relay operates the CA6 relay, which grounds the TFA lead to start a minor alarm and maintains the circuit to the C lamp. If the connector had blocked because of a flase ground holding the GT relay, the operation of the CA6 releases the GT and GT1 relays, letting the call go thru if this was the trouble. If the delay was because of no marker and one is finally seized, or if the call is abandoned, the CA2 and CA4 relays will release, retiring the major alarm. However, relay CA6 will remain locked continuing the minor alarm until released by the operation of the LORL key at the trouble indicator. There is a C lamp on the trouble indicator frame for each connector circuit used to identify the connector involved in a failure.

Operation of the BAT key on the trouble indicator frame causes the C lamp grounded by the operated CA4 relay to light, indicating the connector circuit that timed out. An S lamp also lights, from ground on the SCA relay operated, indicating the sender involved. There are five S lamps, wired to all the connector circuits in common.

While the BAT key is operated, C and S lamps other than the ones indicating the failure may light momentarily, due to calls going through, but the ones involved in the trouble remain lighted steadily.

TIMING FOR RELEASE OF CONNECTOR

If the circuit functions properly up to operation of the MCB relay and consequently does not bring in the alarm as above, the first timing period is cancelled and a second one is started when the MCB and CA5 relays operate. This restart of timing permits a shorter timing interval before the connector alarm is sounded than would be possible if an overall timing period were used. Also, the use of shorter periods with the restart serves as a check in case senders are delayed in engaging a marker.

When the MCB relay operates it operates the CA5 relay and connects ground to the CA2 interrupter, as previously described. The CA5 relay operated removes ground from the CA1 interrupter and releases the CA2 relay, if operated, thus cancelling the first timing period. The CA5 relay also connects ground to the C lamp.

The CA4 relay operates in from 5 to 12 seconds after the MCB relay operates. Ordinarily the connector circuit is released, releasing the alarm relays before the expiration of this period of time. If the circuit is held, however, long enough to operate the CA4 relay as above, ground is connected to the CT lead for sounding the alarm, as previously described. The identity of the connector and sender involved is shown as before when the BAT key is operated.

The CA6 relay cannot operate during the timing for the release of the connector because the CA4 relay is energized only on its primary winding.

If no trouble is encountered during the call, the time measure ends when the MCB relay releases, removing ground from the CA2 interrupter and releasing the CA3 relay, if operated.

ALARMS STARTED IN OTHER CIRCUITS

The operation of an MP relay releases normally operated relays DA1 and DA2 of the marker, as shown in figures 6 and 7, as well as operating the MCB relay. All of these three relays ground the marker TM lead, starting the marker short time-out.

The operation of an MCB relay grounds the marker DB lead, starting the marker long time-out.

If a GT relay is operated and the CA5 relay unoperated for a moment and any marker is idle, some trouble must exist for the connector should then seize the idle marker and operate the CA5 relay. Therefore ground on the TLO key of the trouble indicator frame is connected thru the break contacts of CA relay and make contacts of GT relay to the "GT" lead, thru the break contacts of CBR relay of the idle marker to the "GT" lead of the common timing circuit in the miscellaneous circuit for trouble indicator frame. If this circuit is closed for a short interval, the miscellaneous timing cirucit will disconnect battery from the "B" leads to all connectors, releasing the operated GT relays.

Since miscellaneous timing circuit is very short and gives no indication of which connector is in trouble, provisions are made for cancelling this common timing by means of operating the TLO locking key at the trouble indicator frame and allowing a particular connector to bring in its individual time alarm. The particular connector which times out may be the one whose traffic regulator is in trouble.

TROUBLE DETECTION (CONNECTOR CIRCUIT)

OS-80-1

False ground on any of leads RL, TRL or RO in the connector multiple would send a premature release signal to every sender which seized the connector. In order to detect such false grounds, the windings of the marginal GR relay are connected to these leads while the connector is idle. A false ground will operate the GR relay which locks under control of the RLA key at the trouble indicator frame, lights the GR lamp to indicate the nature of the trouble, lights the C lamp to indicate which connector is in trouble and starts an alarm. To release this alarm the RLA key is operated at the trouble indicator frame.

The GR relay has a non-operate circuit condition to ground thru the winding of the trouble release relays in the sender when the sender enters the connector on a second trial.

The windings of the GR relay are disconnected by the operation of the GRA relay before the marker has time to ground any of the three leads.

CONNECTOR AND MARKER MAKE-BUSY

OS-80-1 & 80-2

A connector may be made busy by the insertion of a short-circuited plug in the GB jack located at the trouble indicator frame. This operates the MB relay which in turn operates the MB relay in each of the associated senders making them all busy. This will prevent any new calls from entering the connector after the senders once complete any calls which they may be handling.

A marker may be made busy at all connectors by the insertion of a short-circuited plug in the DB jack for the marker, this jack being located on the trouble indicator frame. This operates the DB relay, which in turn operates the CBR, CBS and CBT relays, and all associated CB relays. The DB relay opens the DB lead to the marker to prevent a time alarm.

A marker may be made busy at a single connector by means of a CB jack, also located on the trouble indicator frame. One of these jacks is provided for each appearance of each marker in the connectors.

MARKER

MARKER

TANDEM MARKER SD-25361

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TANDEM MARKER CIRCUIT SD-25361

PURPOSE OF CIRCUIT

The marker circuit is used for decoding the office code and for selecting and closing a path from the incoming tandem trunk circuit through the trunk and office link frames to an outgoing trunk. The trunk and office link frames and the office junctor circuits which connect them provide means for connecting any incoming trunk circuit to any outgoing trunk.

DESCRIPTION OF EQUIPMENT

MARKER FRAME

There are from three to eight markers in a crossbar tandem office. Each marker is mounted on a frame including one bay which mounts all the relay equipment of the circuit except the multi-contact relays, another bay which accommodates the multi-contact relays, route relays and the cross-connecting terminal strips for all cross-connections required in a marker.

The marker will function with these maximums: 34 connectors or 170 senders, 20 trunk link frames and 20 office link frames. The 34 connectors do not have any limitation as to the number of each type sender. The total number of senders or connectors, however, will be 170 or 34.

The marker is arranged for 50, 100, 200 or 300 office brush and office group codes, 80 two-digit or 800 three-digit dial codes, 90 service codes and 100 two-digit TX operator codes, or 300 three-digit TX operator codes.

TRUNK LINK AND CONNECTOR FRAME

The trunk link frame is a two bay arrangement, the left bay known as the primary bay and the right known as the secondary bay. These bays obtain their names from the switches that they accommodate. This frame in most cases will be in line and adjacent to its associated trunk frames.

The capacity of this frame is a maximum of 160 tandem incoming trunks, connected by a possible 200 primary-secondary links to a maximum of 200 office junctors which have access to a maximum of 20 tandem office link frames. Its capacity with respect to tandem marker equipment is 8, since this is the maximum number of tandem markers with which the frame is designed to operate. Its capacity with respect to office junctor connector equipment is 20 because this is the maximum number of office frames with which the frame is designed to operate.

The primary bay mounts ten 200-point 6-wire primary switches designated 0 to 9. The 160 incoming trunks are divided into ten groups of 16 trunks each, each group connecting to the horizontals of one primary switch. The upper horizontals 2 to 9 of each vertical in a switch are multipled horizontally and cabled to the trunk frames required for the 160 trunks. The trunk arrangement provides for two trunks to be connected to each of the horizontals 2 to 9 making up the group of 16 trunks in each primary switch.

The two lower horizontal crosspoints 0 to 1 of each vertical in the primary switches are not multipled horizontally, but are both common to the associated link and individual to the vertical multiple strip. The crosspoint contacts of the zero horizontal are only equipped for the No. 3, No. 4 and No. 5 springs, while the crosspoint contacts for the one horizontal are only equipped for the No. 0, No. 1 and No. 2 springs.

Above the primary switches are three relay mounting plates for the marker preference relays MP-0 to 7, emergency relays E-0 to 7, transfer relays TR1, 2, 3, 4 and 5 trouble indicator relay TI and the CH relay.

At the top of the primary bay are two rows of 8 multi-contact relays, one row designated MCA-0 to 7 and the other MCB-0 to 7. These relays serve to connect any one of eight tandem markers which may be involved in a specific call with the test and operating leads of the trunk link frame. The marker connector equipment is variable for use with a minimum of 3 and a maximum of 8 tandem markers.

The secondary bay mounts ten 200-point 3-wire secondary switches designated 0 to 9. All horizontals from 0 to 9 of each vertical in a switch are multipled, except that the multiple is split at the midpoint so as to provide a left group and a right group of ten link terminations per switch.

Above the secondary switches is mounted a terminal strip, to which is wired the variable office junctor for distribution in accordance with standard patterns, as explained later.

At the top of the secondary bay are two rows of 10 multi-contact relays, one row designated JC-0 to 19 and the other LC-0 to 9. The JC multi-contact relays are furnished for the purpose of associating a tandem marker with the required group of office junctors. This depends upon what office link frame is to be selected out of the group of twenty. One JC multi-contact relay is used as two relays, the lower half and its magnet being actuated for one relay, while the upper half and its magnet for the other relay. The JC multi-contact relays are variable in their requirements for a crossbar tandem office, the minimum requirements being five and the maximum ten. When the number of pairs of office link frames exceeds 5, the number of additional multi-contact relays required corresponds to the number of pairs of office link frames. The ten LC relays are furnished for the purpose of associating the tandem marker with the primary switch in which the tandem trunk originating the call is located.

Connecting between the primary switch verticals and the secondary switch horizontals are 200 links. The 200 links, from a distribution standpoint, are divided into 2 similar groups of 100, one group inter-connecting the left halves and on the right halves of the primary switch verticals and the secondary switch horizontals. The 0 to 9 verticals of each primary half switch are connected, one to each of the ten respective 0 to 9 secondary half switches to the horizontal corresponding in number to the primary switch.

The operation of a primary switch crosspoint on any of the levels 2 to 9 connects the associated pair of trunks to the multiple strip of the particular vertical involved from which the even or odd trunk of the pair is extended to the link at the differentiating levels 0 or 1, respectively. This provides a means of extending any one of the 16 trunks which may be assigned to a particular primary switch to anyone of the 20 link outlets on that switch. The outlets for the links between the primary verticals (at horizontals 0 and 1) and the secondary horizontals are the secondary verticals which represent the trunk link frame end of the tandem office junctors.

The trunk links of either the left or the right half switches are used with split trunk levels and the links of both halves may be used with non-split trunk levels.

Office junctors consist of three wires (tip, ring and sleeve) connecting the verticals of the trunk link secondary switches to the verticals of correspondingly numbered office link primary switch. The office junctors on a trunk link frame are always equally divided over all the office frames. The full 200 junctors are installed if this number is equally divisible by the number of office frames; otherwise a few circuits on each frame are omitted in order to provide equal groups. For example, in this office having 6 trunk link frames and 8 office link frames uses an 8x8 pattern. There are 25 office junctors from each trunk link frame to each office link frame. This causes all office junctors on each trunk link frame to be used but only 150 office junctors will be used at each of the office link frames because two trunk link frames in the pattern are not being used on this job.

The addition of trunk link and office link frames to an existing installation if the pattern is fully equipped requires a change in the office junctor distribution. To facilitate changes of this kind, an office junctor grouping frame is provided at which cables from the trunk link frame secondary switches are run vertically and connected to terminal strips on the front of the frame and cables from the office link frame primary switches are run horizontally and connected to opposite ends of the terminals on the rear of the frame. Where cable leads on the front of the frame and cable leads on the rear of the frame terminate on opposite ends of the same terminal, this becomes a permanent condition and is never changed as the office grows.

Where there is less than a maximum number of link frames installed, there will be terminals on each side of the grouping frame which have cable leads attached to one end but not to the opposite end.

These terminals are connected by jumpers. When an addition of link frames is made, and therefore, additional cable is run to both the front and rear of the grouping frame, there will be an increasing number of terminals having cable leads terminating on each end, and therefore, some of the jumpers previously installed will be removed.

OFFICE LINK AND CONNECTOR FRAME

The equipment for the office link and connector frame consists of ten primary switches and ten secondary switches and marker connector relays. The primary switches are 200 point three-wire crossbar switches, their horizontal multiple being cut at the midpoint to provide left and right groups of links in accordance with the left and right groups of office junctors and incoming trunk links. The secondary switches are 200-point four-wire switches, the horizontal multiple of which may be cut at the midpoint or may be continuous to provide split or non-split trunk levels as required by the trunking scheme.

An office "extension" frame is an additional bay of ten secondary switches which is generally located adjacent to the office link frame with which it is associated. These additional extension switches are connected in multiple with the secondary switches to the primary switches of the office link frame so that connections may be established through either set of secondary switches. The switches of an extension frame are 200-point four-wire switches and their horizontal multiple is never cut.

The office link frames are arranged to be operated in pairs with a maximum of twenty frames constituting an office link frame group. The two frames of a pair must be treated in the same way with respect to the presence or absence of extension frames and with respect to the splitting of trunk levels on the link fame secondary switches.

The office junctor circuits are connected to the primary switch verticals of the office link frames, as previously described. Office links consist of three wires (tip, ring and sleeve), connecting the primary switch horizontals to the secondary switch verticals and to the verticals of the extension frame, if provided. There are 200 links per frame, divided into left and right groups, and having access in the primary bay to a maximum of 200 office junctors and in the secondary bay and extension frame, if provided to outgoing trunks. The 0 to 9 horizontals of each left primary half switch are connected in the respective 0 to 9 left secondary half switches to the vertical corresponding in number to the primary switch. The right halves are similarly wired.

All outgoing trunks in the tandem crossbar office are connected to the horizontals of the office link and office extension frames. Outgoing trunk groups are evenly divided between pairs of office link frames, the even numbered trunks being connected to the even numbered frame and the odd numbered trunks being connected to the odd numbered frame. Trunk group assignments may be made in multiples of two and from two up.

With the strapping of the secondary switches left uncut the outgoing trunk capacity of a link frame is 100. This capacity may be increased in increments of 20 trunks each up to a maximum of 200 trunks for the frame by cutting the strapping of two horizontal levels on each switch for each 20 trunk increase. Horizontals cut in this manner have one trunk on the left half accessible to a maximum of 10 left channels and another trunk on the right half, accessible to a maximum of 10 right channels. Horizontals not cut are connected to only one trunk which can be reached through either the left or the right channels.

The 100 trunk capacity frame arrangement will be employed for the larger outgoing trunk groups where the traffic density per trunk is high, while the larger trunk capacity arrangement will be used where a number of small trunk groups with a low density of calls per trunk are connected to a frame.

The office extension frame is intended for use where the outgoing trunks from an office are used in common with either panel or other office link frame groups in crossbar offices in order to provide the necessary trunk access and to load the office link frames efficiently.

In addition to the office junctor terminations, the office links and the trunk terminations described above, the office link and connector frame includes relays wired in a double transfer chain for preventing the simultaneous connection of two markers to the frame and multi-contact test connector and marker connector relays for closing the sleeve leads of the office links and of the trunks to the decoder.

TROUBLE INDICATOR FRAME

The trouble indicator frame is used to give a lamp indication of the particular sender, connector, connector frame and marker involved, together with the office code dialed and other information when a marker fails to function in its time allowance.

CIRCUIT NOTES

DECODING THE OFFICE CODE

SEIZURE OF MARKER

TMS1 - OS- 82

As already described, a marker connector upon seizing a marker releases the DA1 and DA2 relays in the marker, either one operating the TMS1 relay which grounds the TM interrupter for starting the short time-out period as described later.

The release of the DA2 relay operates the RX and STX relays, whose functions at this time is to remove some trouble detecting relays, which guard certain leads during the time that a marker is normal.

The release of the DA1 relay grounds the DB lead to the miscellaneous circuit for the trouble indicator frame, lighting a white lamp to indicate that the marker circuit if off-normal.

CRB, CBS, CBT

The marker connector circuit connects ground to the DB lead operating the CBR and CBS relays, which in turn ground the CB lead to all associated connectors. This causes the selected marker to test busy to all points at which it can be selected. The same DB lead ground is connected to the DB interrupter for starting the long time-out period as described later.

RECEIVING INFORMATION FROM SENDER

When the connector circuit operates its multi-contact relays, closing the receiving leads between the sender and the marker, the marker recording relays operate. This operation will vary depending on whether a dial pulse or revertive pulse sender is involved.

BB5 or BA5 - OS- 83-1, 83-2, 83-3

When a dial pulse sender originates the call, any one of 800 codes may be involved. The operation of the BB5 relay or BA5 relay indicates which half of this code group is to be used. The BB5 relay operates for codes up to 499 and the BA5 for codes up to 999. In this manner it is possible to indicate the hundred by means of an individual lead B-0 to B-4 with one of the above relays operated.

DB5 or DA5

The DB5 relay operates if the B digit is below 5 as recorded on the sender switch crosspoints. If the B digit is 5 or above the DA5 relay will operate. This breaks the hundred codes indicated by the BB5, BA5 and B-0 to B-4 down to a group of fifty codes.

H-2 to H-9
HA-2 to HA-9
H-2' to H-9'
HA-2' to HA-9'

These relays are fifties relays. The H and HA relays operate on all codes that are in the lower fifty group. They operate in pairs as H4 and HA4. Each relay cuts through 25 code points for the codes 400 to 449. The H4' and HA4' will operate for codes 450 to 499. They are under control of the particular B-0 to B-4 lead grounded and the operated DB5 or DA5 relay.

D-0 to D-4

These relays are operated from a D-0 to D-4 lead from the B digit crosspoints in the sender. The operated D- relay breaks the group of fifty codes down to 10.

GB5 or GA5

These relays operate from the C digit crosspoints in the sender. The lower five crosspoints 0 to 4 operate the GB5 and the upper five crosspoints 5 to 9 operate the GA5 relay. This makes it possible to indicate the units by means of the G-0 to G-4 leads.

BB5 or BA5

When the call is from a revertive pulse sender the BB5 relay operates if the office brush registered on the sender crossbar switch is below 5 and the BA5 if the office brush is 5 or above.

FS - OS 83-1, 83-3

The FS relay operates from a ground on the FS lead from the revertive pulse sender.

TN-0 to TN-9

One B lead grounded in conjunction with either the BB5 or BA5 relay and the FS relay operated will operate one of the TN-0 to TN-9 relays. These relays have ten contacts each for 100 code points. The armatures of the TN- relays are multipled together.

GB5 or GA5

These relays operate from the office group registration in the revertive pulse sender. If the group is below 5, the GB5 relay operates and if 5 or above the GA5 relay operates.

G-0 to G-4 Leads

These five leads with an operated GB5 or GA5 relay are connected to the TNO to 9 relay multiple. With a TN- relay operated a code point is grounded.

FB5 or FA5

The FB5 relay is operated when the units digit of the frame indication recorded on the tandem sender crossbar switch is below five, while the FA5 relay operates for above five. The FB5 relay prepares the path for indicating the trunk link frame in the group numbered 0 to 4 or 10 to 14, while the FA5 indicates in the group numbered 5 to 9 or 15 to 19. This indication started from the HA or HB relay of the sender link frame.

F00 or F10

The F00 or F10 relay operated prepares the frame indication to be in the group of trunk link frames No. 0 to No. 9 or No. 10 to No. 19 respectively. This indication starts from the HA or HB relay in the trunk group of the sender link frame, which is transferred to the tandem sender and in turn to the marker.

TR1

The TR1 relay in operating indicates that the tandem sender originating the call is set for a first trial. The TR1 lead is grounded when the sender ON2 relay operates. If the sender is set for a second trial, the TR2 lead is grounded instead of the TR1 lead and the TR2 relay is operated. If the sender is set for a third trial the marker OF relay is operated from ground on the OF lead. In this case neither the TR1 or TR2 lead is grounded.

OS- 83-1

CK1

The CK1 relay receives its operating ground from the CKG lead of the connector through combinations of TR1, TR2, and OF relays and back contacts of ST4 and slow operate TK relays. The CK1 relay checks to see that only one relay of the group TR1, TR2, or OF are operated on any one call. Its path is through the front contacts of TR1 and back contacts of TR2 or the back contacts of TR1 and front contacts of TR2, or the front contacts of OF and the back contacts of TR1 and TR2.

The CK1 relay is taken through the ST4 relay on account of overlapping calls. The marker is so arranged that it can be reselected after having selected an outgoing trunk and before it has completed its marker functions. If there is a call in the marker stage, the ST4 relay is operated preventing the CK1 relay from operating until the ST4 relay has released indicating that the marker stage call has been dismissed.

GPOA to GP1D

Operation of the CK1 relay causes the GPOA, GPOB, GPOC and GPOD or GP1A, GP1B, GP1C and GP1d relays to operate. These relays are used for subgrouping of outgoing trunks and are described later.

OFF-NORMAL PREPARATION

OS- 83-1

CK2

When the CK2 relay operates and assuming that the GW and GZ relays are normal, it closes a path to operate the GW relay and at the same time in parallel shunts the winding of the GZ relay. The GW relay locks. When the CK2 relay releases for this call, the shunt is removed from the GZ relay allowing it to operate.

On the next call when the CK2 relay operates, it shunts the GW relay causing it to release and holds the GZ relay operated. When the CK2 relay releases on this call, the GZ relay releases.

From the above it can be seen that when a marker is selected, the GW and GZ relays will both be normal or both operate at the start of a call.

ST1 and ST2 - OS- 84, 91-7

The operation of the CK1 relay operates the ST1 and ST2 relays in parallel which causes certain relay operations and lead closures to occur in preparation of later functions. The ST1 and ST2 relays connect off-normal ground and battery to the marker and its control relays.

The A, B, C, PT, CHT, HMT, and TM relays are non-biased polarized relays connected differentially. Upon seizure of the marker circuit the armatures of these relays may be in any position. It is, therefore, the function of the ST1 and ST2 relays to place the armatures of these relays on their back contact.

The A, B, and C relays are energized differentially and since in each case the secondary winding has more ampere turns than the primary winding, the effective flux will be from the secondary winding to drive these relays to their back contacts.

The primary and secondary windings of the PT relays are energized, the secondary being the effective for placing the relay on its back contact. Likewise the CHT and TM relays are energized and affected in the same manner.

The HMT relay is energized through its primary winding and may operate. It will release, however, when its secondary winding is energized following the operation of the CHE1 and CHE2 relays.

The primary and secondary windings of the TM relay are energized in a parallel circuit when the ST1 and ST2 relays operate. It is energized in the operate direction on its primary winding but does not operate immediately because the powerful secondary winding is energized in the non-operate direction, driving the relay to its back contact.

OS- 84, 91-7

TKE

When the ST1 relay operates, it operates the TKE relay through 40 K- relays normal as a check on these relays that they have released from a previous call. Later the TKE relay is released as an indication that one of these relays has been operated.

CHE

When the ST1 relay operates, it operates the CHE relay through 20 CH- relays normal as a check on these relays that they have released from a previous call. Later the CHE relay is released as an indication that one of these relays has been operated.

RECORDING TRUNK LINK FRAME NUMBER

FA

The FA relay operates when the marker is selected and provided that it has no call in the marker stage (Selecting a Channel) in which case the ST4 relay is up. If there is a call in the marker stage, leads F-0 to F-4 will be held open at the contacts of relay FA. When that call releases, relay FA will operate through back contacts of relays AK and ST4, and a front contact of the ST1 relay.

The result of the sender grounding one of the F-0 to F-4 leads and either the FB5 or FA5 relay operated and also, when furnished, either the F00 or F10 relay is operated, causes one of the IF-0 to IF-19 relays to operate.

Should some false short or trouble ground cause two of the F-0 to F-19 leads be grounded at the same time energizing two IF-0 to IF-19 relays in parallel, the XIF relay will be operated in a series parallel circuit with the locking windings of the two relays. This relay will not operate, however, when energized in series with only one IF- relay.

AC and AC1

When the ST1 relay operates the AC and AC1 relays operate in parallel. The AC1 relay locks and the AC relay holds in parallel in two separate paths. One locking path is taken through the back contacts of the A relay and the other through the back contacts of the C relay.

OS- 84, 91-7

CHE1 and CHE2

These relays, when operated, open all select magnet leads that will be associated with the trunk link and office link frames and serve to close them again when the marker is ready to close through the selected channel. Their purpose is to place contact protection in the marker when operating the select magnets on the trunk link and office link frames.

SM

The SM relay when operated locks under control of both the S and SL relays.

AK1

The operating primary winding of the marker circuit B relay is short-circuited when the AK1 relay operates. When the ST2 relay operated, as previously described, the B relay closed its back contact. Operation of the AK1 relay causes it to remain normal as at this time its release winding only is energized. The AK1 relay locks through the back contact of the B relay.

SM1

When the SM1 relay operates, it connects battery and ground to the secondary winding of the polarized XSM1 relay in the release direction, thereby putting the armature on its back contact. At this time the primary winding is not energized.

OPERATION OF ROUTE (R) RELAY

OS- 83-3, 85, 88

R-

Code points are terminals appearing in the cross-connection fields of the marker frame. The 100 office brush and group codes (00 to 99) which originate in revertive pulse senders and the 800 three-digit dial codes (200 to 999) from dial pulse senders terminate at code points. The individual G-0 to G-4 had grounded by either sender terminates at the code point involved in the particular call.

The code points are connected to the route (R) relay winding so that the route relay for the code can be operated and control the call. There are several ways in which a route relay can be cross-connected, depending on whether it is a first choice, second choice, overflow or vacant code trunk group. For the purpose of this discussion it will be assumed that the R relay operated is associated with a first choice trunk group.

The code point at the TN- relay or one of the H-HA or H'-HA' relay for a first choice trunk group is cross-connected to the RC punching which is one side of the winding of the route relay assigned to the particular code. The other side of the winding or R punching is cross-connected to the BA, BA1, BB, BB1, BC or BC1 punching depending on the subgrouping of the trunks. This will be described in detail later. In either case the operating battery for the route relay is traced through the winding of the XR relay. The XR relay will not operate being marginal when in series with only one route relay.

If any combinations of leads are grounded that will cause the operation of two of the TN-, H-HA or H'-HA' relays, the result will be two code points grounded operating two route relays. This condition causes the XR relay to operate which blocks the marker and causes it to time-out, as described later.

The R1 or R2 relay operates in series with the route relay and its purpose is to open a timing interval which is being counted for the operation of a route relay. When the R1 or R2 relay operates it causes the recycling of the timing for the next stage by opening the circuit through its back contacts.

One or two route relays are provided for each outgoing trunk group depending upon the trunk subgrouping. On a first trial, the marker is arranged to test successive choices and routes if trunk busy conditions are encountered. On this call, however, it is assumed that an idle trunk will be found in the first subgroup of trunks, tested due to operation of the first route relay and that the battery supply for this relay is furnished through the winding of the R1 or R2 relay.

GROUND SUPPLY GROUP - OS- 86-1, 86-2, 96

The route relays in an office will be subdivided into three ground supply groups as follows: ground supply No. 1, figure 3, ground supply No. 2, figure 36 and ground supply No. 3, figure 4, except when alternate routing is employed in which case there will be five ground supplies. Two, three or five ground supply groups may be provided as follows:

1. When there are no dial pulse, PC1 or multi-frequency senders and the marker is not arranged for alternate routing ground supplies per figures 3 and 4 are provided.

2. When the marker functions with dial pulse, PCl or multi-frequency senders ground supplies per figures 3, 4 and 36 are provided.

3. When the marker is arranged for alternate routing and functions with dial pulse, PCl or multi-frequency senders and revertive pulse senders five ground supplies are provided per first, second and third figure 3, figures 4 and 36.

Ground supply one will have in it the first route relay of trunk groups consisting of three subgroups. Ground supply two will have in it the common route relays of three subgroup trunk groups. It will also have the route relays of single and two subgroup trunk groups. Ground supply three will have the overflow route relays. For the present it will be assumed that the route relay operated is in ground supply figure 36 and that the trunk group is not subgrouped.

When using figure 3 or 36, ground from the normal contacts of the MRL relay is connected to the GS, GE and TL punchings. Ground from the normal contacts of the TB relay is connected to the OB, OG, CR and CL punchings. Resistance battery from the operated contacts of the ST1 relay is connected to the ST punching. The CK2 relay furnishes ground to operate the peg count register if connected to the Z punching when the SM relay operates.

The OB, OG, CL and CR punchings are used for transmitting the decode information to the tandem sender. The ST punching is used to associate with the marker the pair of office link frames on which the desired outgoing trunks appear. The TL punching indicates the trunk level involved on these office frames and the GS and GE punchings determine the "group start" and "group end" points for testing the trunks, thus separating the trunks to the desired destination from any other trunks which may be included within the same test group or trunk level of 40 trunks. The OF and RA punchings are described later.

COMPENSATING RESISTANCE TRANSMITTING RELAYS

CR- OS- 90-2, 90-3, 90-4

The CR punchings at the R relay is cross-connected to a P or S punching of one of the transmitting relays CR-0 to CR-9. This causes leads CR-1-2-4-5 to be grounded in combinations for transmitting compensating resistance requirements for full selector calls and for setting the tandem sender to use the TG or MTG relay as required. On the step-by-step call the CR- relays are used to set the sender CR- relays for a fifth digit indication. The compensating resistance setup in this case is cancelled by the sender.

Ground connected to a transmitting lead is always closed through the winding of a check relay such as CRA, CRB, CRC, or CRD these relays being used to check the continuity of the transmitting leads as described later. The number of check relays provided in a group of transmitting relays is equal to the largest number of leads that can be grounded by this group on any one call.

Flexible cross-connections of this type permit the markers to return to the senders whatever information they may require for a given code and they permit this information to be changed, if necessary, due to changes in routings.

The leads grounded and the relays operated for the various compensating resistance conditions set up in the tandem sender are as follows:

CR Relay Winding	Leads Grounded	Comp. Resis. Off.	Comp. Resis. Beyond Off.	Trunk Guard Relay	Timing and PCl Wipeout	Cont. Relays Operated
CR-0-S	None	900	0	TG	Regular	None
CR-0-P	CR5	900	0	MTG	"	CRA
CR-1-S	CR1	900	300	TG	"	CRB
CR-1-P	CR1-CR5	900	300	MTG	"	CRA-CRB
CR-2-S	CR2	900	600	TG	"	CRB
CR-2-P	CR2-CR5	900	600	MTG	"	CRA-CRB
CR-3-S	CR1-CR2	900	900	TG	"	CRB-CRC
CR-3-P	CR1-CR2-CR5	900	900	MTG	"	CRA-CRC
CR-4-S	CR4	0	0	TG	"	CRB
CR-4-P	CR4-CR5	0	0	MTG	"	CRA-CRB
CR-5-S	TW	900	0	TG	TW	CRB
CR-5-P	TW-CR5	900	0	MTG	TW	CRA-CRB
CR-6-S	TW-CR1	900	300	TG	TW	CRB-CRC
CR-6-P	TW-CR1-CR5	900	300	MTG	TW	CRA-CRC
CR-7-S	TW-CR2	900	600	TG	TW	CRB-CRC
CR-7-P	TW-CR2-CR5	900	600	MTG	TW	CRA-CRC
CR-8-S	TW-CR1-CR2	900	900	TG	TW	CRB-CRD
CR-8-P	TW-CR1-CR2-CR5	900	900	MTG	TW	CRA-CRD
CR-9-S	TW-CR4	0	0	TG	TW	CRB-CRC
CR-9-P	TW-CR4-CR5	0	0	MTG	TW	CRA-CRC

S - Secondary
P - Primary

On step-by-step calls, an arbitary fifth digit may be added to the number to direct an intermediate step-by-step selector. This digit known as a directing digit is supplied by cross-connection at the route relay. The marker CR-relays will transmit this information to the sender by means of the CR leads as indicated by the following chart:

Digit	CR Relay Winding	Leads Grounded	Check Relays Operated
1	CR-0-S	None	None
2	CR-1-S	CR1	CRB
3	CR-2-S	CR2	CRB
4	CR-3-S	CR1-CR2	CRB-CRC
5	CR-4-S	CR4	CRB
6	CR-0-P	CR5	CRA
7	CR-1-P	CR5-CR1	CRA-CRB
8	CR-2-P	CR5-CR2	CRA-CRB
9	CR-3-P	CR5-CR1-CR2	CRA-CRC
0	CR-4-P	CR5-CR4	CRA-CRB

S - Secondary
P - Primary

When one of relays CR-0 to CR-9 is operated through its primary winding, the CRP relay operates in series with it and connects ground through the winding of the CRA check relay to the CR5 lead. This causes the sender to substitute the MTG relay for the TG relay, this condition being required when a ground cutoff non-repeating incoming selector is involved. Operation of the numbered relay through its secondary winding causes the CRS relay to operate and in this case the CR5 lead is not grounded.

The XCR relay is marginal and does not operate unless there is a cross between two or more windings of numbered transmitting relays or a false ground on a winding other than the one used on the call. If it operates, due to a trouble, it causes the circuit to stick and call in the trouble indicator, as described later.

OFFICE BRUSH TRANSMITTING RELAYS

The OB punching at the R relay is cross-connected to one of the transmitting relays OB-0 to OB-4. This causes leads OB1, OB2, OB4 and OB5 to be grounded singly or in combinations for transmitting to the tandem sender the required information for two-wire office brush selections or as the tens digit of the code if a second revertive pulse tandem office is in the route.

When the information sent to the sender is for the purpose of guiding a two-wire office selector the marker will not transmit more than four brush information. If for a second tandem office the marker may send back from 0 to 9 office brush. The following chart shows the leads grounded and the relays operated for the various office brush selections:

Office Brush	OB Relay Winding	Leads Grounded	Check Relays Operated
0	OB-0-S	None	None
1	OB-1-S	OB1	OBB
2	OB-2-S	OB2	OBB
3	OB-3-S	OB1-OB2	OBB-OBC
4	OB-4-S	OB4	OBB
5	OB-0-P	OB5	OBH
6	OB-1-P	OB5-OB1	OBA-OBB
7	OB-2-P	OB5-OB2	OBA-OBB
8	OB-3-P	OB5-OB1-OB2	OBA-OBC
9	OB-4-P	OB5-OB4	OBA-OBB

When office brush selections are not required by the sender to complete its functions, connection will be made in the marker to the secondary winding of the OBO relay. This connection is necessary in order to satisfy the marker in its check operation as described later.

The XOB relay is marginal and will not operate at this time as described for the XCR relay.

OFFICE GROUP TRANSMITTING RELAYS

The marker route (R) relay will have the OG punching connected to one of the OGP or OGS punchings of the OG-0 to OG-5 transmitting relays to send office group information to the sender. Office group information will be necessary in the sender for any one of three reasons. First to guide a two-wire office selector if included in the route. Second as the units digit of the code when a second revertive pulse tandem office is in the route. Third when the call is a step-by-step call that requires a sixth digit.

The leads grounded for office group or sixth digit and the check relays operated are shown in the following chart:

Office Group	Sixth Digit	OG Relay Winding	Grounded	Check Relays Operated
0	1	OG-0-S	None	None
1	2	OG-1-S	OG1	OGB
2	3	OG-2-S	OG2	OGB
3	4	OG-3-S	OG1-OG2	OGB-OGC
4	5	OG-4-S	OG4	OGB
5	6	OG-0-P	OG5	OGA
6	7	OG-1-P	OG5-OG1	OGA-OGB
7	8	OG-2-P	OG5-OG2	OGA-OGB
8	9	OG-3-P	OG5-OG1-OG2	OGA-OGB-OGC
9	0	OG-4-P	OG5-OG4	OGA-OGB
Skip Off.	No Digit	OG-5-S	SO	OGB

When office selections are not required in the sender by a two-wire or second tandem route, connection is made to the secondary winding of the OG5 relay in the marker. This causes the SO lead to be grounded notifying the sender to skip these selections. The SO lead will also be grounded in combination with other relays for four and five digit step-by-step calls.

The XOG relay is marginal and is used to detect trouble as described for the XCR.

CLASS TRANSMITTING RELAYS

The CL punching at the route (R) relay is cross-connected to one of the CL-0 to CL-20 punchings at the marker CL relays. This causes leads IG5, TCI, CI, SD, SD1, OD, XB, SSA, SSB, OB1, RBS and MFA to be grounded singly or in combinations for particular classes of calls.

The information transmitted to the sender varies depending on whether a revertive pulse or dial pulse sender is involved. It can be seen for example that connection to the CL1 punching operates the CL1 relay for a revertive pulse sender and the CL19 relay for a dial pulse sender.

The revertive pulse sender does not require the SD, SD1 or TCI leads so they are connected to resistance battery in the marker by the operated FS2 relay. This is necessary in order to operate the check relays on these leads.

The chart on the following page gives the lead conditions, CL and check relays operated on each class of call for either type of sender.

The XCL relay is marginal and functions as described for the XCR relay.

TL 0/14

The TL punching at the operated R relay is cross-connected to a TL punching at one of relays TL-0 to TL-14. These relays correspond to the trunk levels on the office link frames, of which there may be a maximum of ten, numbered 0 to 9 on a pair of office link frames and five more, numbered 10 to 14, on the associated pair of office extension frames, if provided. The TL relay to which the cross-connection is made corresponds to the trunk level in which the desired trunks are located. Its function is to cause the pair of office frames after they have been associated with the marker to connect the sleeve of the trunks of the proper trunk level to the marker for test.

The following table shows the proper cross-connections, leads grounded, etc., when the marker is arranged for dial pulse, P.C.I. revertive and multi-frequency senders and arranged to function with MF outpulsing senders.

CL X CONNS. - MKR. ARRANGED FOR DP MF P.C.I. AND REVERTIVE SENDERS AND ARRANGED TO FUNCTION WITH MF OUTPULSING SENDERS.

		REVERTIVE SENDERS			P.C.I. DP OR MF SENDERS		
	CL TERM	CL REL. OPD.	LEADS GROUNDED TO SENDER	CONT. RELS. OPD.	CL REL. OPD.	LEADS GROUNDED TO SENDER	CONT. RELS. OPD.
Panel	CL0	CL0	None	(CLA & B)	CL0	SD,SD1	(CLA & B)
Straightforward*	CL1	CL1	CI,OD	(CLA-E)	CL19	OD,TCI,SD,SD1	(CLA-D)
Vacant Code	CL2	CL2	XB,OD	(CLA & B)	CL19	OD,TCI,SD,SD1	(CLA-D)
Crossbar Low Five Incoming Group	CL3	CL3	XB	(CLA-C)	CL3	XB,SD,SD1	(CLA-C)
Crossbar High Five Incoming Group	CL4	CL4	XB,IG5	(CLA-D)	CL4	XB,IG5,SD,SD1	(CLA-D)
SxS, Loop Pulsing "A", Sender Class	CL5	CL5	SSA,OB1	(CLA-D)	CL5	SSA,SD,SD1, RBS or OB1***	(CLA-D)
SxS, Loop Pulsing "A"	CL6	CL6	SSA	(CLA-C)	CL6	SSA,SD,SD1	(CLA-C)
TPCI, Sta. Del. A	CL7	CL7	CI	(CLA & B)	CL7	CI,TCI	(CLA & B)
SxS, Loop Pulsing "B" Sender Class	CL8	CL8	SSB,OB1	(CLA-D)	CL8	SSB,SD,SD1, RBS or OB1***	(CLA-D)
SxS, Loop Pulsing "B"	CL9	CL9	SSB	(CLA-C)	CL9	SSB,SD,SD1	(CLA-C)
Multi-frequency**	CL10	-	-	-	CL10	SSA,MFA,RBS, SD,SD1	(CLA-E)
SxS Battery and Ground Dialing	CL11	CL11	SSA,SSB	(CLA-D)	CL11	SSA,SSB,SD, SD1	(CLA-D)
TPCI, Sta. Del. B	CL12	CL12	CI	(CLA-C)	CL12	CI,TCI,SD	(CLA-C)

CL X CONNS. (Con't.)

	REVERTIVE SENDERS				DP OR MF SENDERS		
	CL TERM	CL REL. OPD.	LEADS GROUNDED TO SENDER	CONT. RELS. OPD.	P.C.I. CL REL. OPD.	LEADS GROUNDED TO SENDER	CONT. RELS. OPD.
TPCI, Sta. Del. C	CL13	CL13	CI	(CLA-C)	CL13	CI,TCI,SD1	(CLA-C)
TPCI, " " D	CL14	CL14	CI	(CLA-D)	CL14	CI,TCI,SD,SD1	(CLA-D)
DPCI, Sta. Del. A	CL15	CL7	CI	(CLA & B)	CL15	CI,TCI,XB	(CLA-C)
DPCI, " " B	CL16	CL7	CI	(CLA & B)	CL16	CI,TCI,XB,SD	(CLA-D)
DPCI, " " C	CL17	CL7	CI	(CLA & B)	CL17	CI,TCI,XB,SD1	(CLA-D)
DPCI, " " D	CL18	CL7	CI	(CLA & B)	CL18	CI,TCI,XB,SD SD1	(CLA-E)
Overflow	CL19	CL0	None	(CLA & B)	CL19	OD,TCI,SD,SD1	(CLA-D)
Official 3 Digit Code Using TPCI Pulsing	CL20	CL7	CI	(CLA & B)	CL1	CI,OD,TCI,SD, SD1	(CLA-E)

* Or 3 digit Opr., traffic from operators only.

** Applies only to senders arranged for M-F outpulsing. All other senders are routed to denied service.

*** RBS - when sender is arranged for M-F outpulsing; OB1 - when sender is not arranged for M-F outpulsing. On classes CL5 and CL8 the OB cross-connection must be cross-connected to OB1S when outpulsing numerals only.

In the above tables, "crossbar low five" and "high five" mean the same as explained in the preceding paragraph. "TPCI" means "tandem call indicator" and "DPCI" means "direct call indicator." "SxS repeated dialing" means dialing by the sender through an outgoing repeater. The four stations delay designations are:

A - Above With - means the called office has both numbers above 9999 and numbers with station letters.
B - Above No - means the called office has numbers above 9999 but no numbers with party letters.
D - Below With - means all numbers in the called office are below 10,000 but there are party letters.
C - Below No - means all numbers in the called office are below 10,000 and there are no party letters.

On step-by-step or multi-frequency outpulsing calls, the sender may send only the numerical digits as received or it may precede these digits with the "C" code digit, the "B" and "C" code digits or the "A", "B" and "C" code digits. These digits may be sent as received or code converted. When code digits are sent code-converted the "A" code digit is obtained from the OB register, the "B" code digit from the OG register and the "C" code digit from the CR register. The following table shows the leads grounded to indicate the number of code digits to send:

Number of Code Digits	Leads Grounded
0	SO
1	SO, 1G5
2	1G5
3	None

The "A", "B" and "C" code digits are determined by the OB, OG and CR cross-connections respectively as shown on the following tables:

OB TERM	LEADS GROUNDED	"A" CODE DIGIT	OFFICE BRUSH	NUMBER OF CODE DIGITS	CONTINUITY RELAYS OPERATED
OS	None	1	0	0 or 3	None
1S	OB1	2	1	0 or 3	(OBB)
2S	OB2	3	2	3	(OBB)
3S	OB1 & 2	4	3	3	(OBB & C)
4S	OB4	5	4	3	(OBB)
OP	OB5	6	5	3	(OBA)
1P	OB1 & 5	7	6	3	(OBA & B)
2P	OB2 & 5	8	7	3	(OBA & B)
3P	OB1, 2 & 5	9	8	3	(OBA, B & C)
4P	OB4 & 5	0	9	3	(OBA & B)
5S	1G5	-	-	1 or 2	(OBB)
5P	1G5, OB5	-	-	TX	(OBA & B)

OG TERM	LEADS GROUNDED	"B" CODE DIGIT	OFFICE GROUP	NUMBER OF CODE DIGITS	CONTINUITY RELAYS OPERATED
OS	None	1	0	2 or 3	None
1S	OG1	2	1	2 or 3	(OGB)
2S	OG2	3	2	2 or 3	(OGB)
3S	OG1 & 2	4	3	2 or 3	(OGB & C)
4S	OG4	5	4	2 or 3	(OGB)
OP	OG5	6	5	2 or 3	(OGA)
1P	OG1 & 5	7	6	2 or 3	(OGA & B)
2P	OG2 & 5	8	7	2 or 3	(OGA & B)
3P	OG1, 2 & 5	9	8	2 or 3	(OGA, B & C)
4P	OG4 & 5	0	9	2 or 3	(OGA & B)
5S	SO	-	Skip Office	0 or 1	(OGB)

CR TERM	LEADS GROUNDED	"C" CODE DIGIT	CONTINUITY RELAYS OPERATED
OS	None	1	None
1S	CR-1	2	(CRB)
2S	CR-2	3	(CRB)
3S	CR-1, 2	4	(CRB & C)
4S	CR-4	5	(CRB)
OP	CR-5	6	(CRA)
1P	CR-1, 5	7	(CRA & B)
2P	CR-2, 5	8	(CRA & B)
3P	CR-1, 2, 5	9	(CRA-C)
4P	CR-4, 5	0	(CRA & B)
10S	CR-2, 4	Cancel Code Conversion	(CRB & C)

With the TL punching cross-connected as described above, the operation of the route relay causes.the TL- relay to operate, corresponding to the trunk level in which the desired trunks are located. The marginal XTL relay is included in this path, but does not operate unless two or more windings of TL relays are crossed or grounded. If it operates, due to a trouble, it blocks the call as described later.

Ground is connected to the even and odd TL leads corresponding to the TL relay operated. These TL leads are multipled at all the even and odd office link frames respectively but will be effective only at the pair of office frames involved in the call due to the arrangement of the office frame marker connector relays described later.

TG- (S) OS- 86-2

The GS punching at the operated R relay is cross-connected to a GS punching at a TG relay in one of the circuits per figure 20. There are ten circuits per figure 20 in the marker, these ten circuits include a total of 40 sets of P, T, K and TG relays. These relays enable the marker to test the 40 trunks of a trunk level simultaneously.

An outgoing trunk group to a particular destination may consist of the 40 trunks of an entire trunk level or any smaller even number of trunks within a trunk level. The TG relay to which the cross-connection is made determines the starting point for testing the trunks and it corresponds to the location of the first trunk to the required destination within the group of 40 trunks.

The marginal XGS relay does not operate when the TG- relay corresponding to the group start point operates. The XGS relay is a trouble detecting relay and will operate only if the windings of two or more group start TG- relays are crossed or grounded. If it operates the call is blocked as described later.

TG- (E)

The GE punching at the operated R relay is cross-connected to a GE punching at a TG relay to determine the end point for testing the trunks. The TG relay used corresponds to the location of the last trunk to the required destination.

The 40 trunks of a trunk level are located alternately on the even and odd office link or office extension frames of the pair. A group start point is always at a trunk on the even frame and a group end point is always at a trunk on the odd frame.

If the trunk link frame involved is an even numbered frame the order of testing trunks is from GS to GE, but if an odd numbered trunk link frame is involved, the order is from GE to GS as described later.

The marginal XGE relay functions described above for the XGS relay.

TRANSMITTING INFORMATION TO THE SENDER

With each of the OB, OG, CL and CR punchings at the route (R) relay cross-connected to the required point in the corresponding transmitting relay groups, as previously described, the decoded information is transmitted to the sender. Closure of ground to the transmitting leads causes required register relays in the sender to operate. The check relays in the marker operate in series with the sender register relays, a check relay being included in each grounded lead. The revertive pulse sender does not require some of the leads to complete its functions. In this case the battery to operate the check relays is furnished at the operated FS2 relay.

The TK relay is used with the check relay to determine whether or not the transmitting leads used on the call are continuous between the sender and the marker and are free from false grounds. Its operating path is traced through operated contacts of relays in each of the CL, OB, OG and CR groups of transmitting relays, the ground being furnished in the CR group.

Within each group of relays the A check relay should be operated if the cross-connection is made to a P punching or the S relay of the group should be operated if the cross-connection is made to an S punching. Either the A or the S relay closes in part the operating path of the TK relay. The check relays of the group, which operate due to the particular transmitting relay being operated, close the path from the A or S relay contacts to the next group of transmitting relays or to ground. If some of the check relays are not required and consequently are normal, their contacts are bridged at contacts of the numbered transmitting relay operated in the group.

With this circuit arrangement, the operating path of the TK relay includes operated contacts of a number of check relays equal to the number of leads required to be grounded. Check relays not required to be operated for a particular call are not required for operation of the TK relay for that call, as their contacts are bridged by operated contacts of S relays and numbered relays as described above.

The TK relay is slow operate in order to allow sufficient time for the register relays in the sender to operate before the connection to the sender is broken down.

If any transmitting lead required for the call should be open, the corresponding check relay in the marker would not operate. Consequently the TK relay would not operate. A false ground on a transmitting lead required for the call by short-circuiting the associated check relay would prevent the operation of the TK relay in a similar manner. If the TK relay fails to operate, the marker times out and calls in the trouble indicator, as described later.

The XT and XT1 relays are provided to detect false grounds and crosses on transmitting leads not required for a call. All transmitting leads not used are connected through normal contacts of the CO relay to the winding of the XT relay, causing its operation if such leads are falsely grounded or crossed with leads used on the call. The XT relay operated operates the XT1 relay which sticks the circuit and calls in the trouble indicator as described later.

TWO OR THREE-DIGIT TX OPERATOR CODES AND SERVICE CODES

As mentioned previously provision is made for 100 two-digit or 300 three-digit TX operator codes and 90 service codes. In the case of a two-digit TX operator code a 1 is registered in the B group, the first digit of the TX operator code in the D group and the second digit in the G group. In the case of a three-digit TX operator code a 1 is not transmitted by the sender but the three digits are registered in B, D and G groups respectively. In each case the EA lead is grounded by the sender instead of the LA lead.

GROUNDING A TX CODE POINT

EA
OS- 83-4, 83-5

Ground on the EA lead causes operation of the EA relay which transfers the DB5 and the DA5 leads from the windings of the DB5 and DA5 relays respectively to the windings of the TXB5 and TXA5 relays respectively.

BB5
OS- 83-1, 83-3, 83-5

In the case of a two-digit TX operator code ground on the BB5 lead operates the BB5 relay.

TXB5
TXA5

Ground on either the DB5 or the DA5 lead through the contacts of the operated EA relay operates either the TXB5 or the TXA5 relay.

GB5
GA5

Ground on either the GB5 or the GA5 lead operates either the GB5 or the GA5 relay.

TX1
TX1'

Ground on the B1 lead through the contacts of the operated BB5 will continue on the TN1 lead through the contacts of the operated TXB5 relay to the FTX1 punching cross-connected to the TX1 punching to the winding of multi-contact relay TX1. In the case of the TXA5 relay being operated the path would be through the contacts of the operated TXA5 relay to the FTX1' punching cross-connected to the TX1' punching to the winding of multi-contact relay TX1'. Thus it can be seen that ground on the B1 lead will operate either the TX1 or the TX1' relay. Operation of the TX1 relay will close through code points TX1 00-49 and operation of the TX1' relay will close through code points TX1 50-99.

DO-D4
R-

Ground on one of leads DO-D4 depending on the first digit of a two-digit TX operator code will operate one of relays CO-D4 while ground on one of leads GO-G4 depending on the second digit of a two-digit TX operator code will continue through the contacts of the GB5 or GA5 relay whichever is operated through the contacts of one of relays DO-D4 through the contacts of the TX1 relay if operated to one of TX punchings 00-49 or through the contacts of the TX1' relay if operated to one of TX punchings 50-99. The ground continues from the TX- punching which is cross-connected to the RC punching of the route relay assigned to the particular TX operator code and causes operation of the R- relay as described under "Operating a Route Relay."

In the case of a three-digit TX operator code the sender does not transmit a one in the "B" group of leads but instead transmits the first, second and third TX operator code digits on the "B", "D" and "G" leads respectively.

OS- 83-5

TXO-9
TXO'-9'

The BB5 or BA5, DB5 or DA5, GB5 or GA5 relays will operate in the usual manner depending on the code, causing the operation of the BB5 or BA5, TXB5 or TXA5, GB5 or GA5 relays. Ground on one of leads BO-B4 through the contacts of the BB5 or BA5 relay whichever is operated, through the contacts of the TXB5 or TXA5 relay whichever is operated, to one of terminals FTXO-9 or FTXO'-9' cross-connected to a corresponding terminal TXO-9 or TXO'-9', will cause the operation of one of relays TXO-9 or TXO'-9' depending upon which lead is grounded.

Ground on one of leads D0-D4 will operate one of relays D0-D4 in the usual manner.

Ground on one of leads G0-G4 through the contacts of the GB5 or GA5 relay whichever is operated, through the contacts of one of the D0-D4 relays whichever is operated to one of the three digit TX code points TX000-TX999 cross-connected to the RC terminal of a particular route relay causes the operation of the route relay.

CROSS-CONNECTION OF TX ROUTE RELAY CONTACTS

OS- 83-4

8TXE
8TXO
TX4A
TX4B

The tandem marker is arranged so that five TX operator trunk groups not to exceed eight trunks per group or ten TX operator trunk groups not to exceed **four** trunks per group may be assigned to the same route relay. It is accomplished in the following manner:

The five TX trunk groups of eight or less trunks each that are to be associated with the same route relay will have code points with different odd second digits or different even second digits. For example, three digit TX codes 112, 132, 152, 172 and 192 would have their respective code points connected to the RC terminal of the same route relay. The contacts of the route relay would be cross-connected in the usual manner except for the GS and GE terminals. The GE terminal would not be cross-connected but the GS terminal would be cross-connected to the 8TXO terminal and when the route relay was operated from any of the above mentioned code points ground on the GS terminal would operate, the 8TXO relay. In addition the GS ground in the marker would be continued over the TXG lead through the contacts of either the TXB5 or TXA5 relay whichever was operated, continuing on either the TXBG or TXAG lead through the contacts of one of the D0-D4 relays operated, continuing as one of leads TX 0-9 through the contacts of the operated 8TXO to the windings of a particular pair of TGE- and TGO- relay to extablish group start and group end. In the case of TX code 112 the TX1 lead would be grounded and the TGEL0 and the TGOR3 relays would operate for the group start and group end of the first group of eight trunks. TX code 132 would ground the TX3 lead and operate the TGEL4 and TGOR7 relays for group start and group end of the next group of eight trunks, etc.

Group start and group end for TX codes with even numbered B digits, 102, 122, 142, 162, etc., would be determined in the same manner except that the 8TXE relay would be operated instead of the 8TXO relay and the even numbered TX-leads would be closed through to the TGE- and TGO- relays.

For TX trunk groups of four trunks per group associated with the same route relay, a maximum of ten TX code points would be cross-connected to the RC terminal of the route relay. In this case the GS terminal of the route relay would be cross-connected to the 4TX terminal and when grounded by the operation of the route relay would operate the TX4B and TX4A relays. Group start and group end points for the ten groups of trunks will be established as described above except that the TX0-9 leads are continued through the contacts of the operated TX4B and TX4A relays to the particular GS and GE points.

GROUNDING A SERVICE CODE POINT

OS- 83-3

1H, 1HA
1H', 1HA'

Service codes are three digit and include codes 100-109, 120-199. 110-119 are never used because of conflict with TX codes. The first digit which is always a 1 will operate the 1H and 1H' relays if the second digit is below 5 thus closing through service code points 000-049, or will operate the 1HA and 1HA' relays if the second digit is above 5.

Excluding these operations, grounding a service code point is the same as described for grounding a three-digit dial pulse code point.

SELECTION OF A TRUNK

OFFICE FRAME SELECTION

OS- 91-2

MP-

At the same time that the route relay causes the decoded information to be returned to the tandem sender, it also causes the desired trunk group to be associated with the marker for test by means of the ST, TL, GS and GE punchings.

The ST punching at the operated R relay is cross-connected to an ST punching associated with the pair of office frames on which the desired outgoing trunks are located. A circuit is provided for each pair of office link frames installed. Operation of the route relay consequently causes the office link and connector circuit MP relay to operate and lock. The operating battery is supplied from the operated contacts of the ST1 relay.

Each even numbered office link and connector frame has an MP relay for each marker, wired as shown in OS-. Each odd numbered office link and connector frame has a duplicate circuit for emergency use. Either the regular or the emergency circuit may be used in connecting the pair of office link frames to the markers, their function being to prevent simultaneous connection to the pair of frames to two or more markers.

The MP relay to operate is the one for the calling marker. It is assumed that it is on the even numbered frame of the pair on which the desired trunks are located and that the TR- relays are normal.

MCA-, OS- 91-2

The office link and connector circuit MCA- relays on both office frames of the pair operate. Each office link and connector frame is equipped with marker connector relays MCA and MCB for each marker. The MCA relays to operate are the ones associated with the operated MP relay.

Two or more MP relays can operate simultaneously. Additional MP relays can operate with the ones for lower numbered markers already operated. The only MCA relays that can operate, however, are the ones corresponding to the MP relay operated for the lowest numbered marker.

MCB-, OS- 91-2

The office link and connector circuit MCB- relays on both office frames of the pair operate. The MCB relays to operate are the ones associated with the operated MCA relays, the grounds being furnished by the ST1 relay in the marker circuit on the even and odd MCB leads. The MCA and MCB relays operated associated the pair of office frames with the marker being used on the call.

OS- 92-5

O-

There is an O relay in the marker circuit for each pair of office link frames installed, these relays being designated 0 to 9 or as required. The one to operate is controlled by the MCA relays operated, either of which connects ground to the corresponding OK lead to the marker. The marginal XOF relay, connected in series, does not operate unless the windings of two or more O relays are crossed or grounded. If it operates, due to a trouble, it sticks the circuit as described later. For this job the O-0 to O-3 relays will be provided.

OS- 92-3, 92-1

PA-

The number of PA relays provided in the marker depends upon the number of office link frames installed, the maximum, however, being five. These relays are designated 0 to 4 or as required, the one to operate being controlled by a cross-connection from the PA punching at the O relay to the PA punching at the required PA relay. They are used to provide additional contacts for use in operating a pattern relay (P), controlled by the combination of the IF relay operated and the O relay operated. The pattern relays are used for blanking out possible office junctor locations, which are not equipped between certain trunk link frames and certain office link frames. This is described in detail later.

TRUNK LINK FRAME SELECTION

OS- 91-5

MP-

Operation of the MP relay in the office link and connector circuit causes the trunk link frame, at which the calling incoming trunk appears, to be selected.

This path is closed from battery through a resistance in the office link and connector circuit, closed over the SB lead to the marker, through the IF relay operated to the ST lead to the required trunk link frame. This path is opened by the XIF relay, should more than one IF- relay operate.

Each trunk link and connector frame has an MP relay for each marker, wired as shown in figures 7, 10 and 11. Each trunk link frame also has a set of E relays, wired in a similar manner, for emergency use. Either the regular or the emergency circuit may be used in connecting the trunk link frame to the markers, their function being to prevent simultaneous connection to two or more markers.

OS- 91-5

DK

When the trunk link frame MP relay operates, it grounds the check lead DK1 to its associated marker to operate the DK relay, which in turn operates the TMS relay. The TMS relay causes a change in the timing circuit, as explained later, because the trunk link frame has been checked for its connection.

OS- 91-5

MCA-
MCB-

The trunk link and connector circuit MCA relay follow the operation of the MP relay and in turn operates the MCB relay. Each trunk link and connector frame is equipped with marker connector relays MCA and MCB for each marker. The MCA and MCB relays to operate are the ones associated with the operated MP relay. Two or more MP relays can operate as described for the MP relays of the office link frame, but the only MCA and MCB relays that can operate are the ones corresponding to the MP relay operated for the lowest numbered marker.

The MCA and MCB relays operated associated the trunk link frame with the marker being used on the call.

CONNECTING THROUGH THE TRUNK LINK FRAME TO INCOMING TRUNK

OS 91-6

SENDER DC TRUNK F

Both the trunk link frame MCA and MCB relays when operated connect ground to the DK lead to the marker circuit. The ground connected to the DK lead is closed through the marker to the DC lead to the marker connector circuit and through this circuit to the tandem sender where it operates the sender circuit DC relay. The DC lead is also connected from the sender through the sender link to the incoming trunk so that the ground connected to the DK lead also causes the incoming trunk F relay to operate.

The path for connecting the ground to the DC lead of the sender is traced as follows: ground on operated MCA or MCB relay, back contacts RL relay, DK1 lead, back contact TB and GT2 relays, No. 11 lead, back contacts TM7, TM9 and ST3 relays, No. 2 lead, front contacts DK relay, DC1 lead, front contacts CK1 relay to marker connector DC lead to sender.

OS 87, 93, 91-6

0 OR 1 PRIMARY SELECT MAGNET TRUNK LINK

When the incoming trunk F- relay operates it causes the No. 0 primary select magnet to operate if its an even trunk or the No. 1 primary select magnet if its an odd trunk. The F relay also connects ground to one of the No. 2 to No. 9 primary select magnets which will not operate at this time. The associated P-2 to P-9 punchings are all strapped to the Z0 punching for this job.

A pair of incoming trunks use the same set of horizontal cross points, the even trunk appearing on the left and the odd trunk appearing on the right, when standing in front of the frame. Therefore, a pair of trunks use the same primary select magnet in the group No. 2 to No. 9.

OS 91-6

LC 0/9 TRUNK LINK

The operating ground for the incoming trunk F relay, originally closed over the DK and DC lead is extended when the F relay operates to the LC lead to the trunk link and connector circuit for operating the LC relay.

There are ten LC relays in the trunk link and connector circuit, each associated with the 16 incoming trunks and the links appearing in one of the primary switches 0 to 9. The LC relay to operate is the one associated with the calling incoming trunk as determined by the operated F relay.

The LS leads of the twenty links available to the calling incoming trunk are connected to the marker.

OS 92-1

AB-

There are ten left and ten right links connecting the verticals of each trunk link primary switch to left and right horizontals of the secondary switches. The horizontals of the secondary switches are of the same number as the primary switches. The 20 LS leads designated 0L to 9L and 0R to 9R, are connected to the secondary windings of the marker AB relays in preparation for channel testing.

The marker includes twenty circuits per figure 15 used for testing the available channels so that an idle one may be selected. The number of channels available for a call depends upon the office junctor distribution and other factors. No more than twenty channels, however, are tested at a time in any case.

A channel consists of a trunk link, an office junctor and an office link; the trunk link and office junctor terminating at the same trunk link secondary switch and the office junctor and office link terminating at the same office primary switch. In addition, the three parts of the channel must all be either on the left halves of the switches or on the right halves, as the trunk link secondary and office primary horizontals are cut at the midpoint and consequently left links and junctors can not interconnect with right links and junctors.

Each circuit per figure 15 is arranged to test the three parts of a channel and to pass it by if one or more parts are busy, in order that the first channel having all of its parts idle can be selected. To accomplish this, the secondary windings of the twenty AB relays are arranged for connection to the sleeve leads of the twenty trunk links; the primary windings of the AB relays are arranged to be connected respectively to the sleeves of the corresponding office junctors, and the secondary windings of the C relays are used to test the sleeves of the corresponding office links. The busy condition on these circuits is ground on the sleeve, consequently any busy link or junctor causes its corresponding relay to operate, thereby preventing the marker from seizing that channel, as described later.

Testing of the office junctors and office links is described later, as these operations do not take place until after the selection of a trunk.

OS- 91-6, 91-7

AK

The ground originally closed over the DK and DC leads used to operate the sender circuit DC relay, the incoming trunk F relay and the trunk link and connector LC relay is extended by operation of the LC relay to the AK lead to the marker for operating the AK relay. Operation of this relay indicates that "A" or trunk link parts of the channels have been connected to the marker.

The AK lead is closed through two contacts of the LC and MCB relays in order to check the operation of both halves of these relays. The strap at the No. 4 armature performs no useful function being provided so that the strapping of the relay may be uniform.

OFFICE LINK FRAME TRUNK LEVELS

TL- AND TR-, OS- 86-2

While the operations in the trunk link and connector circuit described above are taking place, the trunks of the requred trunk level on the office frames are connected to the marker for test.

As previously described, outgoing trunks are connected to the office link secondary switch horizontals and to the horizontals of the office extension frames, if provided. If extension frames are provided, the office links are multipled at the link frame secondary switch verticals and at corresponding verticals of the extension frame, so that a link may be used to connect to a trunk on either frame.

The ten secondary switches of an office link frame, if strapped to provide a continuous multiple on each of the ten horizontals of each switch, have a total capacity of 100 outgoing trunks. This capacity may be varied by splitting the horizontal multiples at their midpoints in accordance with the trunking requirements of the central office. It may be increased to 200 by splitting all 100 horizontal multiples. The intermediate capacities are 120, 140, 160 and 180 outgoing trunks, respectively effected by splitting the 0 and 1, 0 to 3, 0 to 5 and 0 to 7 horizontal multiples of all switches. The office extension frame has a fixed capacity of 100 outgoing trunks, the horizontal multiples never being split.

A test group, whether the associated horizontal multiples or levels are split or non-split, includes trunks assigned to an even level and the next higher odd level on each of the ten regular or extension secondary switches on each frame of a pair. The twenty even numbered trunks are assigned to the even numbered frame and the twenty odd numbered trunks are assigned to the odd numbered frame.

The following table gives the location of all test groups of forty trunks from trunk levels No. 0 to 14, it being assumed that all trunk levels are split. As shown in the trunk level table, the trunks are located alternately on the even and odd frames of the pair, and distributed over the left halves and the right halves of the switches.

If horizontals No. 0 and No. 1, for example, are not split, trunk level No. 1 is omitted. In this case only one test group can be assigned to these locations as the horizontals used for the trunks of trunk level No. 0 are continuous through the switches and cannot be used in the opposite half switch for other trunks.

With respect to non-split trunk levels, therefore, the left and right half switch designations have no significance, except that the office link connector relays used for extending the test leads of the trunks to the marker and the trunk testing relays in the marker are correspondingly designated.

The trunks of trunk levels No. 2 and No. 3 are distributed over the left and right half switches of the even and odd frames as described for trunk levels No. 0 and No. 1, horizontals No. 2 and No. 3 in each switch, however, being used instead of horizontals No. 0 and No. 1. Trunk levels No. 3 is omitted if these horizontals are not split.

The trunks of trunk levels No. 4 and No. 5, No. 6 and No. 7, and No. 8 and No. 9, are distributed in a similar manner being connected to horizontals No. 4 and No. 5, No. 6 and No. 7, and No. 8 and No. 9 respectively. Trunk levels No. 5, No. 7 and No. 9 are omitted if the horizontals involved are not split.

Trunk levels No. 0 to No. 9 are always located on the secondary switches of the office link frames, and trunk levels No. 10 to No. 14 are always located on extension frames. As extension frames are never split the No. 0 and No. 1 horizontals are used for trunk level No. 10, the No. 2 and No. 3 horizontals for trunk level No. 11, etc., as described for trunk levels No. 0, No. 2, No. 4, No. 6 and No. 8 respectively. The distribution of the trunks over the switches of even and odd extension frames is as described for the secondary bays of the office link frames, the left and right half switch designations being used, although the horizontals are continuous.

With one of relays TL-0 to TL-14 in the marker circuit operated as previously described and the operation of the MCA relays on the even and odd office link frames a TL relay and a TR relay on each office frame of the pair operate.

The TL and TR relays are used to connect the test leads of the 40 trunks of the required trunk level to the marker. In an office link frame which has all of its horizontals split, 10 TL relays are provided, designated 0 to 9, each being associated with the correspondingly numbered horizontal in the left half of each of the ten switches. For example, relay TL0 is arranged to connect to the marker the test leads of the trunks wired to the number 0 left horizontals of each of the switches. Relay TL1 in a similar manner connects the No. 1 horizontals to the marker, etc. On a frame of this type ten TR relays are provided, also these relays functioning as for the TL relays but with the horizontals in the right halves of the switches.

Since the trunks of a split trunk level are connected to even numbered horizontals on one-half of a frame and to the next higher odd numbered horizontals on the other half of the frames, it is necessary to associate each even numbered TL or TR relay with the next higher odd numbered TR or TL relay.

Odd numbered TL relays and even numbered TR relays are not furnished for horizontal levels which are not split, and are consequently not furnished in any case for extension frames.

The following table gives the designations of the TL and TR relays which operate (on both office frames) for trunk levels 0 to 14, due to connection of ground by the marker to TL leads 0 to 14 respectively.

STEP 3

TRUNK NUMBERS - TEST GROUP OF TRUNKS

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Location on Frames																				
Frame	E	O	E	O	E	O	E	O	E	O	E	O	E	O	E	O	E	O	E	O
Half	L	L	R	R	L	L	R	R	L	L	R	R	L	L	R	R	L	L	R	R
Sec.Sw.	0	0	1	1	2	2	3	3	4	4	5	5	6	6	7	7	8	8	9	9
Horiz., Trunk Level # 0	0	0	1	1	0	0	1	1	0	0	1	1	0	0	1	1	0	0	1	1
1	1	1	0	0	1	1	0	0	1	1	0	0	1	1	0	0	1	1	0	0
2	2	2	3	3	2	2	3	3	2	2	3	3	2	2	3	3	2	2	3	3
3	3	3	2	2	3	3	2	2	3	3	2	2	3	3	2	2	3	3	2	2
4	4	4	5	5	4	4	5	5	4	4	5	5	4	4	5	5	4	4	5	5
5	5	5	4	4	5	5	4	4	5	5	4	4	5	5	4	4	5	5	4	4
6	6	6	7	7	6	6	7	7	6	6	7	7	6	6	7	7	6	6	7	7
7	7	7	6	6	7	7	6	6	7	7	6	6	7	7	6	6	7	7	6	6
8	8	8	9	9	8	8	9	9	8	8	9	9	8	8	9	9	8	8	9	9
9	9	9	8	8	9	9	8	8	9	9	8	8	9	9	8	8	9	9	8	8
Extension Frame 10	0	0	1	1	0	0	1	1	0	0	1	1	0	0	1	1	0	0	1	1
11	2	2	3	3	2	2	3	3	2	2	3	3	2	2	3	3	2	2	3	3
12	4	4	5	5	4	4	5	5	4	4	5	5	4	4	5	5	4	4	5	5
13	6	6	7	7	6	6	7	7	6	6	7	7	6	6	7	7	6	6	7	7
14	8	8	9	9	8	8	9	9	8	8	9	9	8	8	9	9	8	8	9	9
	First				Second				Third				Fourth				Fifth			
T,K and TG Relay Designations	EL0	OL0	ER1	OR1	EL2	OL2	ER3	OR3	EL4	OL4	ER5	OR5	EL6	OL6	ER7	OR7	EL8	OL8	ER9	OR9
LC Relay Operated	LC0	LC0	LC1	LC1	LC2	LC2	LC3	LC3	LC4	LC4	LC5	LC5	LC6	LC6	LC7	LC7	LC8	LC8	LC9	LC9

	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39
Location on Frames																				
Frame	E	O	E	O	E	O	E	O	E	O	E	O	E	O	E	O	E	O	E	O
Half	R	R	L	L	R	R	L	L	R	R	L	L	R	R	L	L	R	R	L	L
Sec.Sw.	0	0	1	1	2	2	3	3	4	4	5	5	6	6	7	7	8	8	9	9
Horiz., Trunk Level # 0	1	1	0	0	1	1	0	0	1	1	0	0	1	1	0	0	1	1	0	0
1	0	0	1	1	0	0	1	1	0	0	1	1	0	0	1	1	0	0	1	1
2	3	3	2	2	3	3	2	2	3	3	2	2	3	3	2	2	3	3	2	2
3	2	2	3	3	2	2	3	3	2	2	3	3	2	2	3	3	2	2	3	3
4	5	5	4	4	5	5	4	4	5	5	4	4	5	5	4	4	5	5	4	4
5	4	4	5	5	4	4	5	5	4	4	5	5	4	4	5	5	4	4	5	5
6	7	7	6	6	7	7	6	6	7	7	6	6	7	7	6	6	7	7	6	6
7	6	6	7	7	6	6	7	7	6	6	7	7	6	6	7	7	6	6	7	7
8	9	9	8	8	9	9	8	8	9	9	8	8	9	9	8	8	9	9	8	8
9	8	8	9	9	8	8	9	9	8	8	9	9	8	8	9	9	8	8	9	9
Extension Frame 10	1	1	0	0	1	1	0	0	1	1	0	0	1	1	0	0	1	1	0	0
11	3	3	2	2	3	3	2	2	3	3	2	2	3	3	2	2	3	3	2	2
12	5	5	4	4	5	5	4	4	5	5	4	4	5	5	4	4	5	5	4	4
13	7	7	6	6	7	7	6	6	7	7	6	6	7	7	6	6	7	7	6	6
14	9	9	8	8	9	9	8	8	9	9	8	8	9	9	8	8	9	9	8	8
	Sixth				Seventh				Eighth				Ninth				Tenth			
T,K and TG Relay Designations	ER0	OR0	EL1	OL1	ER2	OR2	EL3	OL3	ER4	OR4	EL5	OL5	ER6	OR6	EL7	OL7	ER8	OR8	EL9	OL9
LC Relay Operated	LC0	LC0	LC1	LC1	LC2	LC2	LC3	LC3	LC4	LC4	LC5	LC5	LC6	LC6	LC7	LC7	LC8	LC8	LC9	LC9

Figure 20

TL and TR Relays Operated - Both Frames

Note: Omit odd numbered trunk levels on non-split frames or as required.

Trunk Level		
#0	TL-0	TR-1
1	TL-1	TR-0
2	TL-2	TR-3
3	TL-3	TR-2
4	TL-4	TR-5
#5	TL-5	TR-4
6	TL-6	TR-7
7	TL-7	TR-6
8	TL-8	TR-9
9	TL-9	TR-8
#10	TL-10	TR-10
11	TL-11	TR-11
12	TL-12	TR-12
13	TL-13	TR-13
14	TL-14	TR-14

Trunk Level	TL Relay	TR Relay
0	TL-0	TR-1
1	TL-1	TR-0
2	TL-2	TR-3
3	TL-3	TR-2
4	TL-4	TR-5
5	TL-5	TR-4
6	TL-6	TR-7
7	TL-7	TR-6
8	TL-8	TR-9
9	TL-9	TR-8
10	TL-10	TR-10
11	TL-11	TR-11
12	TL-12	TR-12
13	TL-13	TR-13
14	TL-14	TR-14

Operation of the TL and TR relays, as described above, on both of the office frames connects the S1 and S leads of the 40 trunks of the test group to the marker.

P-

There are 40 sets of P, T, K and TG relays in the marker used for testing the 40 trunks of a trunk level. These relays are designated in order and according to the frame and switch locations of the trunks from EL-0 (even left zero) to OL-9 (odd left 9), as previously given for trunk levels No. 0 and No. 1. These frame and switch locations are always the same for the 40 trunks of a test group regardless of the trunk level used. For example, trunk No. 0 of any trunk level is always on the even frame, left half, switch No. 0 (EL-0); trunk No. 1 is always on the odd frame, left half, switch No. 0, etc.

The P- relays corresponding to busy trunks operate from ground on the S1 leads of the trunks closed at a crosspoint of the secondary or extension switches. Any P- relay that operates, operates its corresponding T- relay.

OS- 91-7

SPE and SPO

The marker circuit SPE and SPO relays or NSE and NSO relays for split or non-split trunk levels respectively, operate when the TL and TR relays on both office link frames operate.

The SPE, SPO, NSE and NSO relays and their associated leads to the office link frames are provided in order to insure closure of the trunk test leads to the marker before the test for an idle trunk is started. These relays are also used to indicate whether the selected trunk level is split or non-split. If the trunks are connected to split levels, it is necessary that this information be recorded in the marker so that it can blankout the channels connected to the left or right half switches which are not available.

The SP and NS leads of figure 4, 5 and 6 of the office link and connector circuit and the NS lead of fugures 14 and 15 are connected or left open as required so that the SP leads from each office link frame to the marker are grounded if the trunk level is split and the NS leads are grounded if it is not split. The ground is closed through operated contacts of both the TL and TR relays to check their operation; the TL-0 and TR1 relays being associated in this way for trunk level No. 0, the TL1 and TR-0 relays for trunk level No. 1, etc., as previously described.

JD OS- 92-4

The JD relay is operated by the SPO or NSE relay, either of which must be operated on a call. When the JD relay operates, it connects ground from the operated contacts of the CK2 relay to the Z punching at the route relay. This is accomplished by using ZI wiring at the GS and GSC relays of the ground supply figures 3 and 36.

The Z punching at the operated R relay is cross-connected so as to record outgoing zone information for the purpose of determining high, low or no charge.

PT OS- 91-7

The PT relay is made slow operate by condenser timing in order to allow sufficient time for the P relays corresponding to busy trunks to operate.

As previously described, operation of the ST2 relay connected battery and ground to the differential PT relay causing it to close its back contact. With the TKE relay operated, operation of the SPE and SPO or NSE and NSO relays removes a short-circuit from the PT condenser. Battery through the release winding of the PT relay then charges the condenser, this charging current holding the relay normal. As the condenser becomes charged, this current decreases until the effect of the operate winding is stronger than that of the release winding, thus causing the relay to operate.

The short-circuit is removed from the PT condenser, allowing the PT relay to operate, only if both of the required split or non-split relays have operated as a check on both of the office frames. Any combination other than the correct combination of the SPE and SPO or NSE and NSO relays prevents the short-circuit from being removed from the PT relay.

OS- 91-7

K-

The PT relay operated closes ground to operate the first K- relay encountered, corresponding to the first idle trunk, which is connected to the testing chain by its associated normal T- relay.

The number of trunks in a trunk group or subgroup may be any number from 1 to 40. With respect to the marker, however, such a trunk group always consists of an even number of trunks which must be assigned in consecutive order beginning at any even number, 0, 2, 4, etc., to 38 and continuing to any odd number, 1, 3, 5, etc., to 39 as determined by the number of trunks required. When the trunk group or subgroup consists of an odd number of trunks, the additional trunk included in the test group for this particular group or subgroup is made busy by grounding its sleeve at the distributing frame. The trunk made busy may be the first, last or any intermediate trunk.

The trunks to the required destination are included between the group start and group end TG relays previously operated and are thus separated from any other trunks that may appear in the same trunk level. The trunks are tested from the group start point to the group end point (left to right through the successive figures 20) if the trunk link frame involved in the call is an even numbered frame; and from the group end point to the group start point (right to left) if the trunk link frame is an odd numbered frame. This is done to equalize the wear, as far as possible, on the relays of the figures 20 and on the crosspoints of the office link frame switches.

If the trunk link frame is an even numbered frame, the ground to operate the K relay is closed through operated contacts of the PT, TKE and IF- relays to lead TR, through normal contacts of the AR1 relay to the group start point, operated contacts of a TG relay to the right through operated contacts of T relay for busy trunks, if encountered, through normal contacts of the T relay for the first idle trunk to the winding of the K relay for that trunk. If the trunk link frame is an odd numbered frame the ground is closed through the PT, TKE and IF- relays to lead TL, normal contacts of the AR1 relay to the group end point, operated contacts of a TG relay and to the left until a normal T relay is found and to the corresponding K relay.

As soon as the bottom 1 and 2 contacts of the K relay close, a ground is connected to the S1 lead of the selected trunk as a busy condition.

RELEASE OF MARKER CONNECTOR CIRCUIT

OS- 84, 91-7

TKE

The TKE relay releases due to operation of anyone of the 40 K relays as its operating path was closed through a chain circuit through normal contacts of all of them.

Release of the TKE relay short-circuits the P condenser and connects ground to the release winding (secondary) of the PT relay. This causes it to release, as under these conditions the release winding overcomes the effect of the operate winding (primary).

OS- 91-7

SR

The operating circuit for the SR relay is traced as follows: battery SR relay, looped through figure 27, front contacts AK relay, back contacts TKE relay, front contacts TK and O- relays, back contacts GT2 and TB relays to ground on back contacts of MRL relay. The SR relay locks to the same ground through the front contacts of the ST1 relay.

The SR relay closes a holding path through the top 8 and 9 contacts for the trunk link and connector circuit MP relay, independent of the contacts of the ST5 relay.

The SR relay locks up the operated TL-, TG-(S) and TG-(E) relays in parallel, through the top 2 and 3 contacts, and operates the ST4 relay through the top 1, 2 and 3 contacts.

The SR relay closes a holding path through the bottom 7 and 8 contacts for the office link and connector circuit MP relay, independent of the contacts of the ST3 relay.

The SR relay closes through the bottom 3 and 4 contacts a locking circuit for the AK relay and in parallel a locking circuit for the LC- relay in the trunk link and connector circuit, the F relay in the incoming trunk and the DC relay in the tandem sender. The AK, LC, F and DC relays were held up to this time by ground from the trunk link circuit DK lead to the marker, extended through the marker connector on the DC lead to the sender, then on the DC lead through the sender link to the incoming trunk LC lead, then on the LC lead through the trunk link to the AK lead back to the marker.

Ground connected by the SR relay is closed in the opposite direction in order to hold these relays after the connection through the marker connector is broken down.

NOTE NO.B46A

ST4

The ST4 relay in operating removes ground from the PC punching at the route relay to the traffic register circuit. It removes ground from the GS, GE and TL punchings at the route relay. As previously described, after release of the connector circuit the marker no longer tests busy and can be reselected.

The second call, however, must not be allowed to progress to a point where it would interfere. For this reason, the TL relay and the TG relays operated for the first call are locked as above when the SR relay operates, and those required for the second call are not allowed to operate at this time.

The ST4 relay connects ground to the MPC punching to operate a marker peg count register.

OS- 91-7

RL LEAD

The SR relay connects ground to the RL lead through the marker connector to the tandem sender operating the tandem sender DRL relay. This causes the marker connector to be released opening all leads between the tandem sender and the marker.

The marker circuit CBR and CBS relays release due to removal of ground from the DB lead by the connector circuit. This removes ground from the associated CB leads to the connector circuits.

The DA1 and DA2 relays operate due to closure of the DA and F leads by the connector circuit.

CK1

The connector circuit removes ground from the CKG lead, releasing the CK1 relay at the same time that the receiving leads are opened. This circuit arrangement prevents the marker from making false operations when the relays connected to the receiving leads release.

The release of the CK1 relay releases the CK2 relay. Ground is removed from the RL lead by the release of the CK1 relay so that if the marker is seized again very quickly, the RL lead will not be grounded and give the second sender a premature release signal.

ST3

The operation of the ST3 relay removes battery from the ST punchings of all route relays associated with this marker. This battery is removed to prevent interference between overlapped calls, as described for the GS, GE and TL contacts. The required office frame MP relay is being held by the SR relay operated.

SELECTION OF A CHANNEL

TESTING THE OFFICE LINKS

LC 0/9 OFFICE LINK - OS- 91-1

As described under "channel testing" the C relays of the 20 circuits per OS- are used to test the sleeves of the office links. This process is similar to the test of the trunk link sleeves, previously described and takes place due to operation of a K relay at the same time that the connector circuit is being released.

When a K relay operates, it identifies the outgoing trunk to be used and consequently the office switch on which the trunk is located. The sleeves of the links which have access to this outgoing trunk are connected for test when the LC- relay operates on the office link frame on which the selected trunk is located.

There are 10 LC relays on each office frame, each LC relay being associated with the 20 links which terminate at a particular secondary switch. The LC relay to operate is the one associated with the links which terminate at the secondary switch on which the selected trunk appears. This is controlled by the particular K relay to operate, which in turn connects ground to one of the 20 LC leads to the even and odd office frames.

Since there are 40 K relays to control 20 LC leads, each LC lead is controlled by two K relays. This is by reason of the fact that a trunk location in the first 20 has a mate in the second 20 or a test group and both appear in the same secondary switch on the office link frame. Therefore, the two trunks in one secondary switch of a test group should control the same LC relay at the office link frame. The circuit is arranged for this condition by having each LC lead wired in a series path with the two associated K relays.

C-

The operation of the office link frame LC- relay and the connection of the LS leads to the marker circuit causes those C- relays corresponding to the busy office links to operate. The busv grounds that operate the C- relays are supplied from the incoming trunk D relays associated with established channels.

There are 10 left and 10 right office links which connect the horizontals of the 10 primary switches (2 per switch) to left and right verticals of each secondary switch, the primary horizontals being of the same number as the secondary switch to which the links are connected.

TESTING THE OFFICE JUNCTORS

EL, OL, ER, OR

Operation of a K relay, in addition to causing the connector circuit to be released and the office links to be tested, as previously described, also causes the available office junctors to be connected to the marker channel relays in order that an idle junctor may be selected.

As previously described the 40 trunks of a trunk level are distributed over the left and right halves of the even and odd office frames. The first trunk of each 4 trunks in the trunk level is always on the even frame, left half; the second is on the odd frame, left half; the third is on the even frame, right half; and the fourth is on the odd frame, right half. The four K relays of each figure 20, consequently are associated with corresponding frames and half switches.

The 10 K relays associated with trunks in the even frame, left half, are arranged to operate the EL relay; those associated with trunks in the odd frame, left half, operate the OL relay, etc. Only one of relays EL, OL, ER or OR operate for a call, depending upon the particular K relay operated.

MCB OFFICE LINK - OS- 91-2

When the EL, OL, ER or OR relay operates, the MCB relay on the office frame not required releases. If the EL or ER relay operates the odd MCB lead is opened, releasing the MCB relay on the odd office link frame. If the OL or OR relay operates the even MCB lead is opened, releasing the MCB relay on the even office link frame.

The reason for releasing the MCB relay not required is to prevent false busy links should a make busy plug be in a PMB jack on the office link frame not required.

JC- MARKER CS- 92-3, 92-5

The JC relays in the marker are used to operate corresponding JC relays in the trunk link frame for connecting to the marker the sleeves of the available office junctors.

As there is a group of office junctors connecting each trunk link frame to each office link frame, the number of JC relays in each trunk link frame and consequently in the marker is equal to the number of office link frames installed. The maximum number is 20, the relays being designated 0 to 19 or as required.

The JC relay to operate is the one corresponding to the office junctor group which connects the trunk link frame involved to the particular office link frame on which the selected trunk is located; this being determined by the 0 relay operated, which corresponds to the pair of office link frames, and by one of relays EL, OL, ER and OR, which identifies the particular frame of the pair. The JC punchings at the marker JC relays are connected in accordance with a pattern to punchings EA-0 to 9 and OA-0 to 9 or EB, EC and ED-0 to 3 and OB, OC and OD-0 to 3 at the 0 relays.

Installations of less than 10 trunk link or office link frames require that "Z" wiring and AJ apparatus be used in figure 17. In this case, a pair of relays (CBA- and CBB-) will be operated. A CBB- relay operated when the JD relay released on the previous call. The CBA- relay operated when the JD relay operated on the present call. It is necessary for a pair of these relays to be operated in order to make the JC relay path effective on such an installation.

When the installation consists of more than 10 trunk link or office link frames "W" wiring will be used in figure 17 and the AJ apparatus will be omitted.

The number of trunk link or office link frame whichever is the greater will determine the type of installation. An office consisting of six trunk link and ten office link frames will be known as a ten frame installation.

To prevent falsely grounded JC lead or two JC leads falsely shorted together from causing the operating of two trunk link and connector circuit JC- relays which might cause double connections; the JC-0 to 19 relays shown in figure 19 are arranged to prevent such an occurrence.

Should a JC lead to the trunk link frame become falsely grounded the trunk link JC- relay winding will be shunted and therefore can not operate. If two JC leads are falsely shorted, then when attempting to use one of these leads the ground that is on the back contact of the JC- relay in the marker will back up over the false short and prevent the operation of either of the trunk link JC- relays involved. If two marker JC- relays are operated, the lower numbered one will open the battery to the contacts of the other and, therefore, only one trunk link JC- relay will be operated.

The "F" ground lead on the contacts of the marker JC- relays as it leaves the ground busbar, is taken first to the JC- relays in figure 19 and then to the MRL relay. This is done so that if the ground lead to the JC- relays should be open it will also be open to the path which operates the SR relay, so that the marker will block in the decoding stage and no attempt will be made to operate a trunk link JC- relay. If the ground lead had been carried to the MRL relay first, then it would be possible for this lead to be open between the MRL relay and the marker JC- relays and the marker would continue to serve calls. Then should two JC leads to the trunk link become shorted, two trunk link JC- relays would be operated without causing the marker circuit to block.

The ground on 1B contacts of the marker JC-0 to 19 relays is to prevent operating two trunk link JC- relays if the 2B and 3B contacts of a marker JC- relay are falsely shorted and if when this relay is operated another JC- relay should be falsely operated.

Should a JC lead to the trunk link become crossed with direct battery or resistance battery, the corresponding trunk link JC- relay may be operated even before the marker is connected. When the marker is finally connected, however, if the JC- relay that is falsely operated is the one to be operated on this call then no harm will be done and the call will progress in a normal manner. If, however, the falsely operated trunk link JC- relay is not to be operated on this call, the ground from the back contact of the marker JC- relay will operate the false battery fuse or, if the resistance in series with the fuse battery is too high to permit the fuse to operate, the ground on the back contact of the marker JC- relay will shunt the false resistance battery, so that in either event the trunk link JC- relay will release.

JC-

When the marker circuit JC- relay operates it connects battery from the ST2 relay through the 150 ohm resistance to the JC lead corresponding in number to the JC- relay operated. The JC leads between the marker and the contacts of the associated MCA relays on the trunk link frames are wired in a uniform slip multiple. On the marker side of the MCA relays the number of the JC lead corresponds to the JC- relay which operates in the trunk link on even number trunk link frames. The JC relay operated on an even trunk link frame also corresponds to the number of the office link frame to which the junctor connects. On the marker side of the MCA relay for odd numbered trunk link frames the even and odd JC leads for each pair of office frames reverse their connections with the corresponding JC relays. That is, the JC0 lead will operate a JC1 relay while the JC1 lead operates a JC0 relay. The JC2 lead operates a JC3 relay and the JC3 lead operates a JC2 relay, etc. This slip is made during the installation of the office so that trunk link frames may be manufactured with the same wiring.

AB-

The operation of the trunk link frame JC- relay connects the sleeve lead of the office junctors to the primary windings of the corresponding **AB-** relay. Busy office junctors have ground on the S leads and cause the corresponding AB- relay to operate if not already operated by its secondary winding due to the corresponding trunk link being busy.

As previously described, office junctor circuits connect verticals of the trunk link secondary switches to verticals of corresponding office primary switches. The number of office junctors in a group varies according to the number of office frames installed but not more than 20 are tested at one time in any case.

At this point the AB relays corresponding to busy trunk links have been operated on their secondary windings, those corresponding to busy office junctors have been operated on their primary windings, and the C relays corresponding to busy office links are operated on their secondary windings. The primary windings of the C relays are used as described later to blank out channels for which no office junctors are equipped and also to cause the marker to pass by all left channels or all right channels when the trunk level involved is split.

TRUNK DOUBLE CONNECTION TEST

DT1-DT2 OS- 84

As previously described when the ST1 relay operated, it operated the DT2 relay which in turn operated the DT1 relay. When the K relay operated, it connected the operating ground for the DT1 relay to the S1 lead of the trunk. This is done to make the trunk test busy to other markers and to panel selectors on trunk group used in common with panel. The double connection test is made when on the the EL, OL, ER or OR relays operate and release the DT2 relay. The release of the DT2 relay removes the operating round for the DT1 relay leaving its winding connected to the S1 lead of the trunk. If the trunk has been seized at some other point and the S1 lead consequently is grounded, the DT1 relay remains operated. Otherwise the DT1 relay releases and allows the marker to continue. The description for what happens if the DT1 relay remains operated is given later.

When the DT1 relay releases, ground is connected to the S1 lead of the outgoing trunk as a busy condition.

XS

The release of the DT1 relay connects the trouble detection XS relay to the trunk S lead. Operation of the XS relay blocks the call causing the marker to time-out.

The S lead is tested in this manner on every call to check for false ground. Such a ground would cause the connection to be held.

OFFICE JUNCTOR PATTERNS

P- OS- 92-1, 93

As previously described, the office junctors on a trunk link frame are always equally divided over all the office frames. The number of office junctors in a group connecting a trunk link frame to a particular office frame can consequently be determined by dividing 200 by the number of office frames installed, any remainder being disregarded in most cases. In a central office having ten trunk link frames and ten office link frames, consequently, there are twenty office junctors in each group. In offices having less than ten trunk link and office link frames there are more than twenty office junctors in each group and in offices having more than ten trunk and office link frames there are less than twenty office junctors in each group.

Each trunk link and connector circuit JC relay has twenty contacts and can consequently connect twenty office junctors to the marker for test. If there are less than twenty office junctors in a group, the locations on the JC relays which correspond to unequipped junctors are caused to appear busy by the operation of a P (pattern) relay. Since the unequipped locations cannot be uniform, the pattern relay selected must conform to the arrangement of the particular office junctor group which connects the particular trunk link frame to the particular office frame used.

The distribution of office junctors can be any one of ten possible combinations for any installation depending on the number of trunk link and office link frames. These combinations and the locations of all the office junctors on the trunk and office link frames are shown on a series of drawings for central offices having from two to twenty trunk and office link frames. On these drawings the light face type indicates permanent connections on the office junctor grouping frame that are never changed as the office grows. The heavy face type represents connections made by jumpers.

The EAP, OAP, EEP, OEP punchings at the IF relays are cross-connected to P punchings at the PA relays as required and the PC punchings are connected to the P punchings at the P relays as required, so that the required P relay will operate under control of the IF and PA relays operated.

When the P- relay operates, the C- relays corresponding to unequipped positions of office junctors operates. The BP punchings at the P relays are cross-connected, as required, to the BP punchings at the C relays.

CK OS- 92-2

The operation of the CK relay is a check that the office link frame LC- and SS- relays have operated. The ground for operating the CK relay is connected at the SS- relay of the office link and the battery is connected at the operated contacts of the marker STX relay.

BK OS- 92-1

The operation of the BK relay is a check that the trunk link frame JC-relay has operated. The ground for operating the BK relay is connected at the JC-relay and the battery at the operated contacts of the STX relay.

In order for the BK relay to operate, one of the CBA1 to CBA4 relays must be operated on any installation under 10 frames or a P (pattern) relay for any installation of 10 frames or more. The CK relay must be operated as well as one of the NSO, SPL or SPR relays. On any call one of these three relays will be operated.

A holding round for the HMT1 relay is connected through the back contacts of the HMT relay when the BK relay operates.

SPT

The SPT relay is made slightly slow release by the EA and EB resistance battery, its function being associated with the short condenser timed time-out, as explained later. The EA and EB resistance causes residual magnetism in the winding of the SPT relay after the BK relay operates holding the relay momentarily.

SELECTION OF A CHANNEL

CHT

When the BK relay operates, it removes the short-circuit from the CHT condenser, allowing it to charge from current through the secondary winding of the CHT relay.

OS- 92-1

CH-

There are 20 sets of AB, C and CH relays in the marker used for testing a maximum of 20 channels. These relays are designated L-0 to R-9 (LO, RO, L1, R1, etc.) in order and conforming to the switch locations of the office junctors at both the secondary of the trunk link and the primary of the office link frames. Each left and right office junctor of the same designation in the group of twenty appear in the switch of the same number. Therefore, there will be two possible office junctors, one left and one right in each of the ten switches of the trunk link secondary and office link primary. These switch locations are always the same for the 20 channels regardless of the trunk link and office link frame combination. The designation of the CH relay indicates the number of the trunk link secondary and office link primary switch selected for the call.

An idle channel is indicated by the AB and C relays for that channel being normal.

When the CHT relay operates, it connects ground to the first pair of AB- and C- relays, and if either one of these relays are operated, the CHT ground is transferred to the next figure 15 by the B and A leads. When this ground meets the first AB- and C- relays of a pair normal, it operates the associated CH- relay through the normal contacts of this pair of relays.

OS- 84, 92-1

CHE

The CHE relay is fast released to prevent the false operation of an additional CH relay if an earlier choice channel became idle at this time, releasing its AB or C relay.

When the CHE relay releases, it connects ground to the RP lead to the trunk link and connector circuit. This ground is closed through the operated MCB relay in the trunk link and connector circuit to the RP lead to the traffic register circuit for scoring a register which counts the number of calls made through the group of 160 trunks associated.

OPERATION OF SELECT MAGNETS

OS- 84

CHE1 & CHE2

The trunk link frame 0 or 1 primary select magnet was operated when the incoming trunk F relay operated, and at the same time the F relay connected ground to one of the primary select magnets 2 to 9. The operation of the select magnet in the group 2 to 9 is under control of the marker and does not operate until the CHE2 relay releases. Each one of the 2 to 9 select magnets are associated with two incoming trunks. When the CHE2 relay releases, battery through the winding of the polarized XSM1 relay is connected to the B lead which is common to the 2 to 9 select magnets. The secondary winding of the XSM1 relay is energized at this time and is being held on its back contact. If only one select magnet operates, the current applied to the primary winding is not sufficient to operate the relay but if two select magnets operate, the XSM1 relay operates and sticks the circuit as described later.

The 2 to 9 rpimary select magnets are operated for as short a time as possible in order to reduce the hazard of double connections when trouble occurs.

The release of the CHE1 relay causes ten trunk link frame secondary select magnets to operate. Ground connected to the SSA lead operates five, one in each of switches zero to four and ground connected to the SSB lead operates five, one in each of switches five to nine. The ten trunk links available for use on the call and have the same designation as the primary switch involved.

The release of the CHE2 relay causes ten office link frame primary select magnets to operate. These select magnets operate in the same manner as the trunk link secondary select magnets over the PSA and PSB leads. The ten office link primary select magnets to operate correspond to the office links available for use on the call and have the same designation as the secondary switch involved.

The release of both the CHE1 and the CHE2 relays causes ten office link frame secondary select magnets to operate. These select magnets are operated in the same manner as above, the CHE2 relay grounding the SSA lead and the CHE1 relay grounding the SSB lead. The ten office link secondary select magnets to operate correspond to the trunk levels in which the selected trunk appears and have the same designation as the SS relay operated.

One of these office link secondary select magnets will be used to close a crosspoint for the selected trunk. The other nine serve no useful purpose on this call.

This arrangement of controlling the select magnets is provided to prevent the contacts on the multi-contact relays in the trunk and office link frames from closing or opening the current through the select magnets.

TIMING FOR RELEASE OF HOLD MAGNETS

OS- 94

HMT

When a channel becomes idle by the removal of the make busy ground from the hold magnets and sleeve leads, an appreciable time is required to release the hold magnets fully and open the crosspoints. To avoid seizure of a circuit during this interval and a possible double connection which might result, the condenser timed HMT relay is employed to introduce a slight delay between the selection of a channel and operation of the hold magnets. The HMT relay is made slow operate by condenser timing as described for the PT relay.

The HMT relay releases the HMT1 relay which disconnects the XS relay from the S lead of the selected outgoing trunk.

OPERATION OF HOLD MAGNETS

OS- 94

A & TRUNK LINK PRIM. HOLD

The release of the HMT1 relay causes the trunk link primary hold magnet, corresponding to the selected channel, and the marker circuit A relay to operate in series.

As previously described when the ST2 relay operated, battery and ground were connected to the differential A, B and C relays, causing them to close their back contacts. the release windings of these relays are stronger than their operate windings when connected in series in this manner with no other battery or ground connected.

Release of the HMT1 relay connects the negative side of the primary and secondary winding of the A relay to the LS lead to the trunk link frame. With the hold magnet battery present and not short-circuited by a false ground, the current flow through the operate winding is increased and the current flow through the release winding is decreased sufficiently to operate the relay.

If the hold magnet battery were not present, the A relay would not operate as the current flow in its windings would not be changed. If the LS lead were falsely grounded, the operate winding of the A relay would be short-circuited and the current flow in the release winding would be increased holding it normal.

Consequently operation of the A relay indicates that the LS lead to the trunk link frame is connected to battery and not falsely grounded.

OS- 94

C & OFFICE LINK SEC. HOLD

The release of the HMT1 relay also causes the office link secondary hold magnet, corresponding to the selected channel, and the marker circuit C relay to operate in series. The C relay operates as described for the A relay. Its operation indicates that the LS lead to the office link frame is connected to battery and not falsely grounded.

If extension frames are provided, a secondary hold magnet and the corresponding hold magnet on the extension frame operate in parallel, and both remain operated throughout the call. The one which is effective in closing a crosspoint is determined by the operated secondary select magnets.

When the secondary hold magnet operates and closes the crosspoints, ground is connected to the S and S1 leads of the selected outgoing trunk.

OS- 84, 94

AC & AC1

In order for the AC and AC1 relays to release at this time, both the A and C relays must operate.

OS- 94

SEC. HOLD-TRUNK LINK
PRIM. HOLD-OFFICE LINK

The release of the AC relay causes the trunk link secondary hold magnet and office link primary hold magnet, corresponding to the selected channel to operate in parallel. The ground for operating these hold magnets is supplied by the AK1 relay, through the back contacts of both the S and SL relays. Operation of the trunk link secondary and office link primary hold magnets extends their operating ground through the crosspoints to the trunk link primary and office link secondary hold magnets, causing the latter to hold or operate. They may not be fully operated at this time as their original operating paths were closed through the windings of the A and C relays respectively, this resistance acting to make them appreciably slow.

CHECK OF TRUNK LINK CROSSPOINTS

OS- 94

A

If the trunk link secondary crosspoint has closed satisfactorily, the marker circuit A relay releases due to closure of direct ground from the trunk link S lead to LS lead which short-circuits the operate winding of the A relay and energizes its release winding.

Release of the A relay checks the closure of the crosspoint on the trunk link secondary switch.

OS- 94

SL

If the trunk link primary crosspoint has closed satisfactorily, the same ground that shunted down the marker A relay, is extended through the S lead to the incoming trunk, through the operated F relay to the SL lead, through the operated LC- and MCB relays to the marker, operating the SL relay.

Operation of the SL relay checks the closure of the crosspoint on the trunk link primary switch.

The operation of the SL relay connects an additional ground to the A relay holding it normal and removes the A relay from the LS lead to the trunk link and connector circuit.

CHECK OF OFFICE CROSSPOINTS

OS- 94

C

If the office link primary crosspoint has closed satisfactorily, the marker circuit C relay releases due to closure of direct ground from the trunk link S lead to the office LS lead, which short-circuits the operate winding of the C relay and energizes its release winding. Release of the C relay checks the closure of the crosspoint on the office primary switch.

OS- 94

S

If the office link secondary crosspoint has closed satisfactorily, the same ground that shunted down the marker C relay is extended through the S lead, through the operated TL or TR and MCB relays to the marker, operating the S relay.

Operation of the S relay checks the closure of the crosspoint on the office link secondary switch.

Operation of S relay connects an additional ground to the C relay holding it normal. Ground through the C relay winding is removed from the LS lead to the office link and connector circuit. Ground from the marker circuit is removed from the S1 lead to the outgoing trunk.

OS- 95

SIK

Operation of the SIK relay checks for the connection of ground to the S1 lead at the crosspoint of the office link secondary switch.

RELEASE OF TRUNK LINK AND OFFICE SELECT MAGNETS

OS- 84

SM

When the SL relay operates on the check of the trunk link primary crosspoints and the S relay on the check of the office link secondary crosspoints, both locking circuits for the SM relay are opened causing the SM relay to release.

The release of the SM relay moves ground from trunk link B, SSA and SSB leads and the office link PSA, PSB, SSA and SSB leads releasing all select magnets except the trunk link 0 or 1 primary.

SLEEVE LEAD TEST - TRUNK LINK AND OFFICE FRAMES

OS- 94

B

After the LS leads and the crosspoints have been checked as above, a check of the completed sleeve circuit through the trunk link and office link frames is made as follows:

Operation of the SL relay disconnects the windings of the A relay from the LS lead to the trunk link frame and connects them to ground, holding the relay normal, as previously described. In a similar manner, operation of the S relay disconnects the windings of the C relay from the LS lead to the office frame and connects them to ground. In addition, the SL and S relays in operating each open parallel paths from the windings of the B relay to grounds at the AK1 relay. With these paths open, the windings of the B relay are connected only to the S lead to the trunk link and connector circuit.

This S lead is connected directly to the trunk link secondary and office primary hold magnets, and is closed through the corresponding crosspoints to the trunk link primary and office secondary hold magnets, and through their crosspoints (and contacts of the incoming trunk F relay) to the SL lead from the trunk link frame to the marker and to the S lead from the office frame to the marker. The SL and S relays are connected, respectively, to these leads.

The battery to operate the B relay consequently comes from the windings of the trunk link and office primary and secondary hold magnets and the marker circuit SL and S relays, in parallel. Operation of the B relay indicates that these magnets and relays and the leads described above are free from ground, as the presence of a false ground at any point in this circuit would prevent the B relay from operating as described for the A relay.

OS- 84, 94

AK1

The operation of the marker B relay releases the AK1 relay and removes ground from the AK lead releasing the trunk link LC relay, the incoming trunk F relay and the tandem sender DC relay which was held up over the DC lead through the sender link crosspoints. Release of the DC relay is a signal for the sender to proceed with selections.

The release of the trunk link MCB relay opens the RP lead to the traffic register circuit.

OS- 94

B

Release of the incoming trunk circuit F relay connects ground to the S lead to the trunk link and connector circuit. This ground is used to hold the trunk link and office link hold magnets during the conversation and it also short-circuits the operate winding of the B relay and increases the current flow through its release winding, causing it to release. Release of the B relay indicates that the incoming trunk circuit has functioned to connect the holding ground.

This ground remains connected during the conversation. When the calling subscriber disconnects, the incoming trunk circuit removes the ground, releasing the operated hold magnets.

RELEASE OF MARKER CIRCUIT

OS- 86-3, 95

MRL

When the B relay releases, indicating that the channel hold magnets have been locked, the MRL relay is operated through the back contacts of the B relay and causes the marker to release.

The MRL relay locks under control of numerous operated relays which must release before the MRL relay can release.

With the MRL relay released and the CK1 relay again operated, due to another call having started in the decoder stage, then the ST1 and ST2 relays will again operate and the next call will advance into the marker stage.

OS- 84

DLX

The release of the ST1 relay removes ground from the winding of the DLX relay which starts to release. This relay is made slow release so that the STX relay, which is held operated from its contacts will not release before the office link and connector circuit has released. Should the STX relay release first, the XCH relay would be falsely operated. The STX relay will not release on calls where the CK1 and ST1 relays are again operated before the DLX relay has had time to release.

PROVISIONS OF ROUTE RELAYS

The marker holding time provides that up to 120 trunks, in three test groups of 40 trunks each, may be tested during one operation of the marker. The three groups of trunks which can be tested are two outgoing groups of trunks and one group of overflow trunks.

For regular trunk groups of 1 to 40 trunks provide one route relay for each outgoing trunk group consisting of not more than 40 trunks.

For regular trunk groups of 41 to 80 trunks provide one route relay for each outgoing trunk group of two subgroups, each subgroup consisting of not more than 40 trunks.

For regular trunk groups of 81 to 120 trunks provide two route relays for each outgoing trunk group of three subgroups, each subgroup consisting of not more than 40 trunks.

When the overflow route relay is operated in any marker, the cross-connections are such that the marker will direct the call to overflow trunks.

Vacant codes are routed to the overflow trunks. A separate route relay is assigned to the vacant code routing; however, due to the fact that the class indication to the sender must be different than for an overflow routing.

GROUPING OF ROUTE RELAYS
GROUND SUPPLY GROUPS OS- 86-1, 86-2, 96

A maximum of 120 route relays are provided on each marker frame. Additional route relays when required can be provided by installing supplementary frames. These frames are mounted adjacent to the marker and provide an additional 120 route relay and their cross-connection fields per frame installed.

The route relays are divided into ground supply groups. The number of ground supply groups provided and the number of route relays in each group is predetermined by traffic requirements.

120 trunks can be tested on one call. The overflow trunks must be tested when a dial pulse sender is involved in the call and all outgoing trunks are found busy.

If the call is from a revertive pulse sender and all outgoing trunks are found busy, the overflow trunks are not tested. The outgoing trunk route relays, however, are common to both types of senders and are in the same ground supplies in either case.

GROUND SUPPLY GROUP 1, FIGURE 3

In this ground supply are located all route relays of the first two subgroups of trunks of three subgroup routings.

The armatures of these route relays are multipled together and connect to the G and GS relays of figure 3. With this arrangement the controlling leads of all route relays in this ground supply group will be opened when the G and GS relays operate.

GROUND SUPPLY GROUP 2, FIGURE 36

The second group of route relays are in ground supply group 3, figure 36. These route relays are associated with routes having a single group of trunks, routes having two subgroups of trunks and the third subgroup of trunks of routes having three subgroups.

The armatures of these route relays are multipled together and connectedto the GC and GSC relays to open the control leads, should trunk testing advance to ground supply 3.

FIGURE 4

The second group of route relays are in ground supply 2, figure 4. These route relays are associated with routes having a single group of trunks, routes having two subgroups of trunks, the third subgroup of trunks of routes having three subgroups and the overflow route.

The control leads of these route relays are not connected to relays as they are in ground supply group 1 because there is no further progress in trunk testing after this ground supply.

CROSS-CONNECTION OF ROUTE RELAY WINDING

RC TERMINAL OS- 83-3, 85, 88

For regular routes of 1 to 80 trunks, each of which require one route R relay, The RC terminal of the winding will be cross-connected directly to the desired "C" and/or "C-RV" code point.

For regular routes of 81 to 120 trunks, each of which require two R relays, the RC terminal of the first choice route relay will be cross-connected directly to the "C" and/or "C-RV" code point. The RC terminal of the second choice of common route relay will be cross-connected to the RA terminal of its associated first choice R relay.

The overflow route of 1 to 40 trunks will have one route relay.

REVERTIVE PULSE SENDERS ONLY

The overflow route relay will be in ground supply group 2, figure 4. The RC terminal of this route relay is cross-connected to the COF terminal. It can be seen that the overflow route relay is only operated when required by the sender as indicated by a ground on the OF lead from the sender. As previously mentioned, on all trunks busy condition in this office does not require that the overflow trunks be tested.

DIAL PULSE, MULTI-FREQUENCY, OR PCI SENDERS IN ADDITION TO REVERTIVE PULSE SENDERS

The overflow route relay will be in ground supply group 3, figure 4. The RC terminal of this route relay is cross-connected to the COF terminal and to the RA terminals of all route relays in ground supply 2, figure 36.

When the call originates in a revertive pulse sender an all trunks busy condition does not require the overflow trunks to be tested. The class of service relay, FS1, figure 34, forces the operation of the TB2 relay in figure 4 before the overflow trunks are tested.

The dial pulse sender causes the marker to test the overflow trunks on an all trunks busy condition. In this case the operated OPR class of service relay, figure 34, causes the overflow route relay to operate.

There will be one route relay for all vacant codes. This route relay will be in ground supply group 2. The RC terminal is cross-connected to all "C" and "C-RV" code points of vacant codes and to the VC terminal of figure 29.

R PUNCHING OS- 83-3, 85, 88

For regular routes of 1 to 40 trunks having only one trunk subgroup, cross-connect the R terminal of the route relay winding directly to the BA terminal. This causes the R1 relay to operate in series with the route relay when the code point is grounded.

For regular routes having exactly two trunk subgroups, cross-connect the R terminal of the route relay winding directly to the BB terminal. This causes the R2 relay to operate in series with the route relay when the code point is grounded.

For regular routes of 81 to 120 trunks or having three trunk subgroups, there will be two route relays for this size trunk group. The R terminal of the first choice route relay will be cross-connected directly to the BA terminal and the R terminal of the second choice or common route relay to the BC terminal.

The R terminal of the overflow route relay will be cross-connected to the BC terminal.

FOR THE TRUNK GROUPS NOT SUBDIVIDED

Terminals ST and TL determine the pair of office frames and trunk levels on which the outgoing trunks appear, while GS and GE mark the group start and group end points in the trunk level of 40 trunks.

These terminals are cross-connected directly without reference to the grouping relays from route relays associated with figures 4 and 36 to whatever points may be required for the particular trunk group. The number of such route relays or trunk groups is limited only by the number of codes.

The terminals of the overflow and vacant code route relays are exceptions. These terminals connect to the armatures of the relays in figure 34. The contacts of these relays connect to the required points.

FOR TRUNK GROUPS HAVING TWO OR THREE SUBGROUPS OR TRUNKS

The ST, TL, GS and GE terminals from the route relays assigned to trunk groups having two subgroups and the first choice route relays of trunk groups having three subgroups of trunks are cross-connected to the contacts of the GPOA to GPOD relays and the GP1A to GP1D relays. The GPOA-D relays are operated on one call and on the next call, the GPOA-D relays release and the GP1A-D relays operate.

The ST, TL, GS and GE terminals from the route relays are cross-connected to a set of corresponding GC- terminals on the GPOA, GPOB or GPOD relay and a set of corresponding GC- terminals on the GP1A, GP1B, GP1C or GP1D relays. The two corresponding sets of GP- terminals on the two GP relays are cross-connected to the required points for the two subgroups involved. Only one of these sets of terminals will be closed at any one time because only all the GPO relays or all the GP1 relays can be operated at any one time. The calls on an average will be distributed evenly to the two subgroups.

On trunk groups divided into only two subgroups, regardless of which subgroup of trunks tests busy, the other or mate subgroup will be tested before an all trunks busy condition is registered and an overflow signal is transmitted to the sender as described under "All Trunks Busy."

Each of the GP relays has 60 contacts so that on any call the four relays close 240 contacts. Since four contacts are needed for each trunk group subdivided into two or three subgroups, then by dividing 240 by 4, we obtain 60 which is the maximum number of these trunk groups that can be provided for. In offices where the number of these trunk groups is 15 or less, then only the GPOA and GP1A relays need be furnished. If the number of such trunk groups is more than 15 but less than 31, then the GPOB and GP1B relays will also be furnished. For 31 to 45 such trunk groups, GPOA to GPOC and GP1A to GP1C relays are furnished. All eight of the GP- relays will be furnished where there are more than 45 of these two or three subgroup trunk groups.

Z, PC AND OF TERMINALS OS- 83-3, 87

The PC terminal on the route relay is cross-connected to operate a register for peg count of the calls attempted in a group of trunks.

The path to operate the register is carried through contacts of the SM relay to prevent a possible false operation. This condition might occur if a second call were waiting in the decoder stage and the ST4 relay released before the JD relay released on the call in the marker stage.

When the OB indication is required for completing calls, the Z punching is used for peg count and ZH wiring. This allows the PC terminal to be used for the OB indication.

On trunk groups that have two route relays, the Z or PC terminal of only the first choice route relays will be cross-connected. The Z or PC terminal of the second choice route relay will not be cross-connected because if it were then the trunk group peg count message register would be operated twice for one call whenever the second choice route relay was operated on finding all trunks of one of the first choice trunk subgroups all busy.

The OF terminal on the route relay is provided to furnish a means for operating a message register and record the number of calls originated for a trunk group when all trunks of the group are found busy.

On trunk groups that have but one route relay, the OF terminal of the route relay associated with figure 4 or 36 is cross-connected. On trunk groups that have two route relays, the OF terminal of the second choice route relay and which will also be associated with figure 4 or 36, will be cross-connected.

The ground lead to the PC or Z and OF terminals is opened on contacts of the DMT relay so that these registers will not be operated on sender test calls or marker test calls. It is also carried through a back contact of the ST4 relay to prevent operating the register while there is a call in the marker stage.

CROSS-CONNECTION OF RA TERMINAL OS- 85

REVERTIVE PULSE SENDERS ONLY

Routes that have one route relay (R) will have that relay located in ground supply group 2, figure 4. In this case the RA punching is not cross-connected. This is due to the previously mentioned fact that the overflow route relay is not operated when all trunks are found busy. The disposition of a call on an all trunks busy condition will be described later.

REVERTIVE PULSE SENDERS ONLY

ROUTE (R) RELAY CONNECTIONS

Ground Supply Group	Route (R) Relays	RC Terminal	R Terminal	PC Terminal	OF Terminal	RA Terminal	ST,TL GS,GE Terminals
1 Fig. 3	First of 3 Subgroups	Code Point C-RV	BA	To Register	Not Connected	To RC of Common Subgroup	GC-ST) GC-TL) Fig. GC-GS) 6 GC-GE)
	Single Group	Code Point C-RV	BA	To Register	To Register	Not Connected	Direct
2 Fig. 4	Two Subgroups	Code Point C-RV	BB	To Register	To Register	Not Connected	GC-ST) GC-TL) Fig. GC-GS) 6 GC-GE)
	Common of 3 Subgroups	RA of 1st Route Relay	BC	Not Connected	To Register	Not Connected	Direct
	Vacant Codes	Code Point C-RV	BA	To Register	To Register	Not Connected	Direct
	Overflow	COF	BC	To Register	To Register	Not Connected	Direct

ROUTE (R) RELAY CONNECTIONS

DIAL PULSE, PC1, OR MULTI-FREQUENCY

AND REVERTIVE PULSE SENDERS

Ground Supply Group	Route (R) Relays	RC Terminal	R Terminal	Z or PC Terminal	OF Terminal	RA Terminal	ST,TL GS,GE Terminals
1 Fig. 3	First of 3 Subgroups	To Code Point C and/or C-RV	BA	To Register	Not Connected	To RC of Common Subgroup	GC-ST) GC-TL) Fig. GC-GS) 6 GC-GE)
2 Fig. 36	Single Group	To Code Point C and/or C-RV	BA	To Register	To Register	To RC of Overflow R-Relay	Direct
	Two Subgroups	To Code Point C and/or C-RV	BB	To Register	To Register	To RC of Overflow R-Relay	GC-ST) GC-TL) Fig. GC-GS) 6 GC-GE)
	Common of 3 Subgroups	RA of 1st Route Relay	BC	Not Connected	To Register	To RC of Overflow R-Relay	Direct
	Vacant Codes	Code Point C and/or C-RV and VC	BA	To Register	To Register	To RC of Overflow R-Relay	CS-ST1) CS-TL1) Fig. CS-GS1) 34 CS-GE1)
3 Fig. 4	Overflow	To RA of all Route Relays of Grd. Supply 2 and COF	BC	To Register	To Register	Not Connected	CS-STO) CS-TLO) Fig. CS-GSO) 34 CS-GEO)

Routes that have two route (R) relays will have the first route relay located in ground supply group 1, figure 3. The RA terminal of this route relay will be cross-connected to the second route relay RC terminal. The second route relay is in ground supply 2, figure 4, and does not have its RA terminal connected.

Route relays for overflow trunk groups will be in ground supply group 2, figure 4 and will not have the RA terminal connected.

The RA terminal of a route relay is not grounded and is, therefore, ineffective to operate a succeeding route relay unless a trunks busy condition is encountered.

DIAL PULSE, PCI, OR MULTI-FREQUENCY AND REVERTIVE PULSE SENDERS

Routes that have one route (R) relay will have that route relay located in ground supply group 2, figure 36. In this case the RA terminal of the route relay is cross-connected to the RC terminal of the overflow route relay.

Routes that have two route relays will have the first route relay in ground supply group 1, figure 3. The RA terminal of this route relay is cross-connected to the RC terminal of the second route relay. The second route relay being in ground supply group 2, figure 36 and its RA terminal being treated as above for routes having one route relay.

The overflow route relay is in ground supply group 3, figure 4 and does not have its RA terminal cross-connected.

The RA terminal of a route relay is not grounded and is, therefore, ineffective to operate a succeeding route relay unless a trunks busy condition is encountered.

ROTATION OF CALLS TO TRUNK SUBGROUPS

GPOA-GP1D OS- 86-1

In order to distribute as evenly as possible the traffic through the various units of the office frames as well as to distribute calls to the different trunk subgroups of large trunk groups, the marker is arranged to route the calls successively to different subgroups of trunks.

This is controlled by the operating and releasing of the CK1 and CK2 relays and their action on the GW and GZ relays of figure 11 causing the GPOA to GP1D relays to operate and release.

At the start of a call when the CK2 relay has operated, the GW relay operates and the GZ relay is short-circuited. The CK1 relay grounds leads OA, OB, OC and OD through the break contacts of the GZ relay operating the GPOA, GPOB, GPOC and GPOD relays of figure 6. At the completion of this call, the release of the CK1 relay releases the GPOA to GPOD relays. The release of the CK2 relay causes the GZ relay to operate and the GW relay to hold.

On the second call the operation of the CK2 relay short-circuits the GW relay which releases and the GZ relay holds. The operation of the CK1 relay operates the CP1A, GP1B, GP1C and GP1D relays. At the completion of this call, the release of the CK1 relay releases the GP1A to GP1D relays. The release of the CK2 relay releases the GZ relay.

On the third call it functions the same as the first call operating the GPOA to GPOD relays.

With the above arrangements, then on successive calls, the GPOA-D and GP1A-D relays are alternately operated. The ST, TL, GS and GE terminals from the contacts of the route relay, of routes having trunk groups divided into two or three subgroups are cross-connected to the controls of the GP- grouping relays. In this manner successive calls are distributed to the two subgroups associated with ground supply figure 3 and 4 or 3 and 36 depending on the type of tandem office.

ALL TRUNKS BUSY CONDITIONS

These conditions will be described on the basis of the sender involved as well as the type of tandem office. This is done due to the fact that the city tandem office disposes of an all trunks busy condition in two different ways, depending on whether a revertive or dial pulse sender is used. The interzone tandem office, while it also has revertive pulse senders, differs from the city tandem procedures due to the difference in the ground supply layout. Each case will be described individually.

SINGLE GROUP (REVERTIVE PULSE SENDERS ONLY)

A routing with a single group of trunks will have the route relay associated with that group of trunks located in ground supply group 2, figure 4.

PT

Due to all T- relays between the group start and ground end points being operated, the operation of the PT relay causes the TBL relay to operate.

TBL

The path to operate the TBL relay is traced from battery at the TBL winding through operated TGS relay, all operated T- relays in trunk group operated TGE relay normal or operated AR1 relay depending on what trial is registered in the marker, operated IF- relay, operated TKE relay, operated PT relay to ground at the operated ST2 relay.

The operated TBL relay disconnects the operating battery from the K- relays. This is done to insure that the marker will not select a trunk should one become idle once the marker has registered an all trunks busy condition.

The TBL relay opens the ground to the transmitting leads to the sender, releasing the register relays operated. This is not only to release these relays in the sender but also to allow time for the energy in their windings to be dissipated before the TB relay operates and the CL and CR relays release, closing the XT relay winding to the transmitting leads. If this should occur too quickly the XT relay might operate falsely due to the inductive discharge from the windings of the sender relays.

TB OS- 86-1

The TB relay operates due to the TBL relay operation. The TB relay in operating releases the MCB relay on each office link frame and operates the TB2 relay.

TB2 OS- 87

The TB2 relay in operating, grounds the RO, TRL or both leads depending on what trial is recorded in the marker on the TR1, TR2 and OF relays.

With the TR1 relay operated indicating a first trial, the RO lead is grounded to the sender. This will cause the sender to send back a premature reverse battery to the originating sender.

The TR2 operated causes the TRL lead to be grounded causing the tandem sender to make a third trial.

The OF operated causes the marker to ground both the RO and TRL leads. This causes the tandem sender to disconnect and leave the call without any connection.

The grounding of either or both leads causes the sender to disconnect from the marker releasing the marker.

SINGLE GROUP (REVERTIVE SENDERS)

A routing with a single group of trunks will have the route relay associated with that group of trunks in ground supply group 2, figure 36.

PT

Due to all T- relays between the group start and group end points being operated, the operation of the PT relay causes the TBL relay to operate.

TBL

The path to operate the TBL relay is traced from battery at the TBL relay winding through the operated TGS relay, all operated T- relays in the trunk group, operated TGE relay normal or operated AR1 relay, depending on what trial is registered in the marker, operated IF- relay, operated TKE relay, operated PT relay to ground at the operated ST2 relay.

The TBL relay in operating disconnects the operating battery from the K- relays. This prevents a K- relay from operating if a previously busy trunk becomes idle while the marker is advancing to dispose of the call due to the previous all trunks busy condition.

The TBL relay opens the ground to the transmitting leads to the sender, releasing the register relays operated. This is not only to release these relays in the sender but also to allow time for the energy in their windings to be dissipated before the TB relay operates and the CL and CR relays release, closing the XT relay winding to the transmitting leads. If this should occur too quickly the XT relay might operate falsely due to the inductive discharge from the windings of the sender relays.

The TBL relay locks to the DK lead of the trunk link and connector. This is done to insure the release of the trunk link frame when successive groups of trunks are to be tested and is not removed in this case.

TB

The TB relay operates due to the operation of the TBL relay. In operating, the TB relay releases the MCB relay of each office link frame and causes the operation of the TBC relay. The TB relay locks through the normal GC and GSC relay contacts to insure that they are operated before releasing.

TBC OS- 86-2

The TBC relay operates the GC and GSC relays. The GC relay opens the OG, CL and OB terminals of the route relay and the GSC relay opens the ST, TL, GS and GE terminals. In this case only the ST lead is required to be opened. The dial pulse sender, however, requires that all leads be opened. The reason for this will be described at that time.

The TBC relay connects ground to the OF terminal of the route relay to indicate an all trunks busy condition by means of a register scoring.

The opening of the ST lead causes the release of the office link frame. Release of the office link frame causes the release of the trunk link frame.

PT (RELEASE)

The PT relay releases when the office link frame has released and in turn released the NSE, NSO or SPE and SPO relays. Release of these relays drive the PT relay to its back contacts.

The SPE, SPO or NSE and NSO relays release either due to the office link releasing or the opening of the TL lead to the office link frame releasing the TL and TR relays in the office link frames.

TBL (RELEASE)

The TBL relay releases when the PT relay has released and the trunk link has removed the ground from the DK lead.

The release of the TBL relay causes the TB relay to release releasing the TBC relay.

TB2

The release of the TBC relay with the FS1 relay operated on a revertive pulse sender call causes the TB2 relay to operate.

The TB2 relay in operating, grounds the RO, TRL or both leads depending on what trial is recorded in the marker on the TR1, TR2, and OF relays.

With the TR1 relay operated, the RO lead is grounded causing the sender to send back a premature reverse battery to the originating office.

The TR2 relay operated causes the TRL lead to be grounded. Ground on the TRL lead causes the tandem revertive pulse sender to make a third trial.

The OF relay operated, grounds both the RO and TRL leads. In this case the tandem revertive pulse sender leaves the call without any connection.

The grounding of either or both leads cause the sender to disconnect from the marker releasing the marker.

DIAL PULSE SENDER

When this type of sender is connected to the marker for a call involving an all trunks busy condition, the call proceeds as follows:

The route relay can be considered to be the same relay as the one considered for the revertive pulse sender. Route relays in most cases are common to both types of senders. There may be some cases that are individual to a type of sender.

The dial pulse sender requires that when all trunks are found busy, the overflow trunks be tested and call be completed to one of these trunks if possible. This is due to the fact that there is no sender at the originating office to receive the premature reverse battery as in the case of the revertive pulse sender.

The call proceeds as for the revertive pulse sender up to the operation of the TBC relay. The GC and GSC relays operate and open the terminals of the original route relay. This is necessary in this case because the overflow route relay in operating will set up new route information in both the sender and marker. The OB, OG, CL and CR register relays in the dial pulse sender are released by the operation of the TBL relay. The OB, OG, CL and CR transmitting relays and the TL, GS and GE relays in the marker are released by the operation of the TB, GC and GSC relays. The office link frame is also released by the operation of the GSC relay.

The call proceeds as for the revertive pulse sender up to the release of the TBC relay. Due to the fact that a dial pulse sender is attached, the OPR relay is operated.

TBC (RELEASE)

The TBC relay in releasing with the OPR relay operated, grounds the RA lead of the original route relay. This lead being cross-connected to the RC terminal of the overflow route relay causes it to operate.

ROUTE RELAY (OVERFLOW)

The overflow route relay in operating, sets up information in the marker as the original route relay did and the call proceeds as a normal call selecting an overflow trunk if available and disconnects in the normal manner.

ALL TRUNKS BUSY IN FIRST OF TWO SUBGROUPS

The marker will function exactly the same way for either the city or interzone tandem office when proceeding from one subgroup of trunks to the next in a two subgroup routing.

The only difference in this case is the ground supply in which the route relay is located.

Interzone tandem will have route relays associated with two subgroup routings in ground supply group 2, figure 4.

City tandem will have route relays with this type of trunk subgrouping in ground supply group 2, figure 36.

R2 OS- 85

For this condition one route relay is provided for 80 trunks or less divided into two subgroups. The route relay R terminal is cross-connected to the BB terminal of the R2 relay.

GW & GZ OS- 86-1

It is assumed for this call that the GW and GZ relays are normal when the marker is selected. When the CK2 relay operates, the GW relay is operated and the GZ relay short-circuited.

GPOA-GP1D

For this condition the ST, TL, GS and GE terminals are cross-connected to the GPOA to GP1D relays as previously described making it possible to select one of two test group locations and if all trunks are found busy in this subgroup, they are disconnected and the second subgroup is selected for test.

When the CK1 relay operates it causes the GPOA, GPOB, GPOC and GPOD relays to operate through the normal contacts of the GT2 relay.

GT1

When the code point is grounded the route and R2 relays operate in series. With the GW and R2 relays operated, a path is closed to operate the GT1 relay.

This path is traced through contacts of the GW and GZ relays, one of which is operated and the other normal. The GT1 relay operated opens the operating path of the TB relay and prepares for the testing of the other subgroup in case all of the trunks in the first subgroup tested are found busy.

GT2

When the PT relay operates for the selection of a trunk with the GT1 relay operated and under the assumed condition that all the trunks in the first subgroup tested are found busy, the TBL relay in operating operates the GT2 relay.

The GT2 relay closes a locking path for the GT1 relay and removes ground from the MCB leads of the office link frames. It also opens the DC lead to the marker connector releasing the sender circuit DC relay, the incoming trunk F relay, the operated LC relay in the trunk link and connector circuit and the marker AK relay. The DC lead is opened so that the F relay will be fully released before the marker disconnects from the trunk link frame to prevent it from remaining falsely operated if the trunk link frame should be seized immediately upon its release by another marker.

The operating of the GT2 relay causes the GPOA, GPOB, GPOC and GPOD relays to release. Release of the operated GP relays, as above, removes ground from the ST, TL, GS and GE cross-connections for these relays. This releases the office link and trunk link frames and the operated trunk level, group start and group end relays. The marker O and PA relays and the SPE and SPO or NSE and NSO relays, whichever were operated, release due to the release of the office frames.

In this case it is not necessary to release the transmitting relays previously operated as the information required by the sender is the same for all the trunks of a group, regardless of its division into subgroups. It is necessary, however, for the marker to disconnect from the first subgroup of trunks tested and connect to the other.

GT3

The release of the office link frames release the NSE and NSO or the SPE and SPO relays. The release of these relays causes the secondary winding of the PT relay to be energized and driven to its back contact. With the PT relay on its back contact and the GT1 and GT2 relays operated, a path is closed to operate the GT3 relay. The GT3 relay operated removes the short circuit from the GZ relay which operates and releases both the GT1 and GT2 relays.

The GT2 relay in releasing closes the path for operating the GP1A, GP1B, GP1C and GP1D relays which operate from ground on the CK1 relay.

The relays to operate at this time are the ones that were normal at the beginning of the call, the change from one pair to the other having been accomplished by the operation or release of the GZ relay.

The ST, TL, GS and GE terminals at the operated route relay are now closed through the operated GP- relays to the required points for connection of the other subgroup of trunks to the marker. The office link and trunk link frames function as before and the call proceeds in the regular manner provided that an idle trunk is found in this subgroup. The GT3 relay releases when the operated R2 relay releases on the completion of the call.

ALL TRUNKS BUSY IN FIRST OF THREE SUBGROUPS OS-86-3

The marker functions in this case are identical for markers serving revertive and dial pulse senders.

The only difference is in the location of the route relays in the ground supply groups.

Trunk groups that are divided into three subgroups require two route relays, the first route relay being in ground supply group 1, figure 3. The second route relay is in ground supply 2, figure 4 for the interzone office and figure 36 for the city tandem office. The first route relay provides for 80 trunks or less, divided into two subgroups and the second route relay provides for one subgroup of 40 trunks or less.

The route relay in figure 3 has its RC terminal connected to the code point while its R terminal is connected to the BA terminal using the R1 relay. Under this situation of three subgroups, the R2 and GT1 relays are not used because only one or the other of the two subgroups on the first route relay is tested on any one call. The ST, TL, GS and GE terminals are cross-connected to the GC terminals of the GP- relays. The GP terminals of the GP- relays are in turn cross-connected as required.

Interzone tandem has the CL, CR and PC terminals connected from the route relay to the CL- and CR- transmitting relays as required. The PC terminal is connected to a peg count register.

City tandem has the CL, CR, OB, OG and Z terminals cross-connected at the route relay. The CL, CR, OB and OG terminals are connected to the CL-, CR-, OB- and OG transmitting relays respectively. The Z terminal in this case is cross-connected to the peg count register.

The OF terminal is not cross-connected on the first route relay.

If an idle trunk is not found in the first subgroup tested, then when the PT relay operates, the TBL and TB relays operated, in turn, operating the TB1 relay of figure 3.

Under this condition, the TB relay opens the DC lead, releasing the operated sender DC relay, the trunk F relay, the trunk link LC relay and the marker AK relay.

Operation of the TBL relay moves ground from the transmitting leads and operation of the TB relay releases the transmitting relays.

Removal of ground from the transmitting leads causes all the operated sender register relays to release. This is done so that they may be reoperated in accordance with the requirements of the next trunk group which is to be tested.

GS

The GS relay in operating removes ground from the TL, GS and GE terminals releasing the associated relays and battery from the ST terminal, releasing the office link frames, which in turn release the trunk link frame.

Release of the office link frames releases the NSE and NSO or SPE and SPO relays, which cause the PT relay to be driven to its back contact.

TMS1 & TMS2

When the trunk link frame in releasing removes ground from the DK1 lead, the DK relay releases in turn releasing the TMS and TMS2 relays and disconnects ground from the TM interrupter. The release of the TMS2 relay reoperates the TMS1 relay and reconnects ground to the TM interrupter to recycle the timing for trunk testing.

R

When the trunk link frame in releasing removes ground from the DK lead, it releases the TBL, TB and TB1 relays. Release of the TB1 relay with the GS relay operated causes ground to be connected to the RA terminal of the operated first choice route relay, thereby operating the second choice route relay.

Operation of the second choice route relay closes the start lead to the office frames and another pair or the same pair are connected. Ground is again connected to the transmitting relays and the proper registration is made in the sender. The trunk level, group start and group end relays, corresponding to the second choice relay subgroups are operated. The circuit now functions for selecting an idle trunk in the second choice subgroup of trunks, as in a regular call.

LAST OF TWO SUBGROUPS

LAST OF THREE SUBGROUPS

When a two subgroup routing or the last subgroup of a three subgroup routing is being considered, the marker disposes of the call as for all trunks busy in a single subgroup.

REVERTIVE SENDERS ONLY

The route relays for trunk groups of two subgroups and the route relays associated with the last subgroup of three subgroup routing will be located in ground supply group 2, figure 4.

DIAL PULSE AND REVERTIVE SENDERS

The route relays for trunk groups of two subgroups and the route relays associated with the last subgroup of three subgroup routings will be located in ground supply group 2, figure 36.

These route relays are in the same ground supply group as route relays for single trunk groups. It can be seen, therefore, that when the second subgroup of a two subgroup routing or the last subgroup of a three subgroup has all the trunks busy, the call is disposed of as for a single group routing.

OVERFLOW CALLS

REVERTIVE SENDERS ONLY

The interzone tandem marker will test the overflow trunks when the OF relay is operated indicating a third trial by the sender.

The route relay for the overflow routing is located in ground supply group 2, figure 4. The RC terminal of this route relay is cross-connected to the COF terminal. The R terminal is cross-connected to the BC terminal.

As the route relay is in ground supply group 2, figure 4, there is no further progression in trunk testing if all the overflow trunks are found busy.

The OF relay being operated indicates a third trial causing the marker to ground both the TRL and RO leads to the tandem sender. Ground on both of these leads causes the sender to disconnect and leave the incoming trunk without any connection.

The operations in the marker in disposing of a call with all overflow trunks busy is identical to the functions detailed under all trunks busy in a single group.

The revertive pulse sender when connected to the marker can be connected to an overflow trunk only on third trial calls. This is due to the fact that the overflow route relay cannot be operated on any call on which all trunks are found busy when such a call comes from the revertive pulse type sender. The class relay FS1 being operated disconnects the ground from the RA lead and uses this same ground to force the operation of the TB2 relay as described before under "all trunks busy single group."

The operated OF relay on third trials grounds the COF terminal operating the overflow route relay.

If an all trunks busy condition is encountered on the overflow trunks, the operation of the TBL and TB relays causes the TB2 relay to operate. The operated TB2 relay connects ground to the RO and TRL leads causing the sender to disconnect and release the marker. In this case the call is left high and dry without a connection and without any signal to the originating operator.

The marker on a call from a dial pulse sender will proceed to the overflow trunks when all other trunks are found busy.

Finding all the trunks associated with a route relay in ground supply 2, figure 36, busy, will cause the marker to function as for all trunks busy single group. The release of the TBC relay connects ground to the RA terminal of the route relay in ground supply 2. The calls of service OPR relay being operated causes the overflow route relay to operate. The marker proceeds to select an overflow trunk completing the call in the normal manner.

The overflow trunks may be tested first on a third trial call. In this case the OF relay is operated by the dial pulse sender.

The original route relay operates when the marker is seized.

OF

The OF relay being operated on a dial pulse sender third trial call causes the G, GS, GC and GSC relays to operate.

The ground that operates the GS relay is extended through its operated contacts to the RA lead to operate the next route relay in ground supply two. The original route relay terminals are not effective because they are opened by the operated G and GS relay.

The ground that operates the GSC relay is extended through its operated contacts to the RA lead to operate the overflow route relay in ground supply three. The second route relay terminals are not effective because they are opened by the operated GC and GSC.

This leaves only the overflow route relay contacts effective, routing the call to an overflow trunk on a third trial from a dial pulse sender.

If the original route relay is in ground supply two, the operation of the G and GS relays serves no purpose.

If an all trunks busy condition is encountered on the overflow trunks, the operation of the TB2 relay with the OF relay operated,causes ground to be connected to the RO and TRL leads. This disposes of the call as for a revertive pulse sender.

VACANT CODES

A vacant code can result from a wrong office brush and group registration.

The vacant code route relay is located in ground supply 2, figure 4, and is operated from the code point grounded by the wrong OB and OG registration.

The call proceeds as for a single group of trunks and terminates to an overflow trunk due to the cross-connections of the vacant code route relay.

An all busy condition on the trunks proceeds as previously described for "all trunks busy single group."

REVERTIVE PULSE SENDER

A vacant code may result from a wrong office brush and group registration.

The vacant code route relay is located in ground supply group 2, figure 36, and is operated from code point grounded by the wrong OB and OG registration.

The call proceeds as for a single group of trunks and terminates to an overflow trunk due to the cross-connections of the vacant code route relay.

An all trunks busy condition proceeds as previously described for "all trunks busy single group," for the revertive pulse sender.

DIAL PULSE SENDER

A vacant code will be due to operator's dialing or wrong registration of that dialing.

The vacant code route relay is the same relay as for the revertive sender. The call proceeds as mentioned above.

An all trunks busy condition in this case causes the overflow route relay to be operated.

This results in the trunks being retested. If the trunks are again found busy the call proceeds as for "all trunks busy single group" described for the dial pulse sender.

SECOND TRIAL

TR2 OS- 83-1, 96

The sender is arranged to make a second trial after receiving a trouble release signal for any reason except due to all trunks being found busy. It also makes a second trial after receiving a regular release signal, if it encounters an overflow or telltale condition from the terminating office.

The sender in making a first trial to put a call through, grounds the TR1 lead operating the TR1 relay. On second trial calls, the TR2 relay is operated.

When the ST1 relay operates on a second trial call with the TR2 relay operated, the BF relay operates, in turn operating the AR1 and AR2 relays in parallel. The AR1 and AR2 relays cause the testing for an idle trunk to be made in the opposite direction to that used on a first trial. On first trial calls, the testing starts from the TGS relay if an even IF- relay is operated or at the TGE relay if an odd IF- relay is operated. The AR1 and AR2 relays also cause the shift of the start and end points for channels testing. In both cases, this is an attempt to avoid the reselection of a trunk or channel in the second trial which may have been in trouble on the first trial.

OF

If the OF lead is grounded with either the TR1 or TR2 lead, if it is the first or second trial, the OF relay operates for the selection of an overflow trunk as already explained. When the ST1 relay operates with the OF relay up, the OF1 relay operates.

THIRD TRIAL

On third trial calls the OF relay is operated forcing the marker to select an overflow trunk.

This was described in detail for each type of office under "Overflow Calls."

FAILURE OF SPE, SPO, NSE OR NSO RELAYS

If any one of relays SPE, SPO, NSE or NSO fails to operate on a first trial call due to an open lead or to the failure of the MCA, TL or TR relay and assuming that the relay is required for the call, the PT relay is prevented from operating. This causes the marker to time out, call in the trouble indicator as described later and send a trouble release signal to the sender. The sender then makes a second trial as previously described causing the BF, AR1 and AR2 relays in the marker to operate.

If the trouble also occurs on the second trial, the trunks on the office frame that failed to check in are caused to appear busy so that a trunk on the other frame may be selected. This is accomplished as follows: assuming that one of the even frame relays failed to operate due to a trouble in the office frame or in the lead between the office frame and the marker.

XBE & XBO

When the AR1 relay operates and assuming that the SPE or NSE relay failed to operate, the XBE relay operates. Should the SPO or NSO relay have failed, then when the AR1 relay operates, the XBO relay operates.

BF

When either the XBE or SBO relay operates the BF relay releases. The BF relay is slow release to allow time for both of the required relays to operate if one should be slightly slower than the other for any reason.

BE & BO

When the BF relay has released, the BE relay operates due to the XBE relay being up. If the XBO relay is operated, then when the BF relay releases the BO relay operates.

If one relay of the pair SPE and SPO or NSE and NSO is slower than the other but operates before the BF relay releases, it releases the XBE or XBO relay, whichever is involved and consequently the BE or BO relay respectively does not operate, as in such a case it is not necessary to make the trunks on one frame busy.

When either the BE or BO relay operates, it connects the NS lead from the even office frame to the NS lead of the odd office frame or the SP lead from even office frame to the SP lead of the odd office frame or vice versa, respectively. Now since one of these four leads will be grounded, this ground will be extended to the associated lead from the mate frame and will force the operation of the NSE, NSO, SPE or SPO relay, whichever one of these relays that should have operated but did not.

If the BE relay operates, it also makes all even trunks appear busy by operating all even T- relays, while if the BO relay is operated all odd T- relays are operated.

After the proper pair of SPE, SPO, NSE and NSO relays are operated, the short circuit is removed from the PT condenser, allowing the PT relay to time and operate. The circuit advances from this point as in a regular call, except that due to the even or odd numbered T relays being operated, only the odd or even numbered trunks are available for selection. With this arrangement it is possible to set up a connection to out trunks on one frame even though the mate frame is out of service.

The XBE and BE relays or the XBO and BO relays, whichever are used, release when the ST1 relay releases. Release of the BE or BO relay causes the corresponding T relays to release.

If a failure such as the above occurs due to a trouble in the relay itself or in the wiring in the marker, and the relay consequently does not operate at all, the marker times out and calls in the trouble indicator again as on a first trial. A stuck circuit is also caused if, due to trouble conditions, three or all four of these relays should operate, as in such a case the PT relay cannot operate.

SUCCESSIVE CALLS - 8X8 JOB

OS 92-6, TO 96-12

JUNCTOR PATTERNS

As already stated the office junctors on a trunk link frame are always equally divided over all the office link frames. The number of junctors between any trunk link and any office link frame is, therefore, obtained by dividing 200 by the number of office frames or trunk link frames, whichever is the larger.

The detail results of this division for the various frame arrangements is shown in the following chart:

No. of Frames	Tot. No. of Junctors	Number of Junctors in Test Choice				
		A	B	C	D	E
2	100	20	20	20	20	20
4	50	20	20	20*	20**	10
6	33	10	20	20**	20**	3
8	25	20	20*	20*	20*	5
10	20	20				
12	16	16				
14	14	14				
16	12	12				
18	11	11				
20	10	10				

* Same junctors as A test choice
** Same junctors as B test choice

From the above chart it can be seen that on jobs with 12 or more office frames there are not 20 junctors or channels available as is the case also in the A test choice of the six frame job and the E test choice on the four, six or eight frame job. On jobs with 2, 4, 6 or 8 frames, more than 20 junctors are available and are arranged in choices A to E.

In those choices where there are less than 20 office junctors the pattern relays provide the necessary blanking out or make busy condition in those locations of the channel test where the office junctors are not available.

On the 20 frame job and on the A test choice of six frame jobs, the pattern relay operates directly through the contacts of the IF- relay because from a particular trunk link frame the junctor pattern to all even office frames and to all odd office frames is the same. In all other cases when there is a pattern, the pattern relay operates through the contacts of the PA relays as well as the IF relays. This is because from a particular trunk link frame the junctor pattern is not the same for all odd office frames and all even office frames.

The following chart indicates the number of patterns used and in what choices:

No. of Frames	Tot. No. of Pattern Relays	Number of Patterns in Each Choice A	B	C	D	E
2	None	None	None	None	None	None
4	2	None	None	None	None	2
6	14	2	None	None	None	6*
8	8	None	None	None	None	4*
10	None	None				
12	10	10				
14	10	10				
16	10	10				
18	10	10				
20	2	2				

* Two pattern relays operated in parallel for each pattern.

P- & PA-

In an 8 x 8 job, there are eight pattern relays P-0 to P-7 and operated in pairs. There are also four pattern auxiliary relays PA-0 to PA-3. Each pattern relay is capable of blanking out ten channels by operating the associated C- channel relays and making them appear busy. Since on this job there are 25 junctors for each choice, 20 are test on first test and if all are found busy, the remaining 5 are tested on a second channels test. No blanking out is required on a first test but having only 5 junctors for a second test, it is necessary to blank out 15 channels, which is cared for by having two pattern relays in parallel.

The contacts of the pattern relays are cross-connected to BP terminals on the windings of the C- relays to obtain the required pattern. These cross-connections together with others that are required for this pattern are shown in a pattern drawing.

The pattern relays P- are operated from the same source and at the same time as the marker JC- relay, and the particular pattern relays that are operated depends upon the trunk link and office link frame involved.

The following chart indicates the marker JC- relays selected in all office groups:

MARKER JC RELAY SELECTION

8 X 8 JOB

Office Group-0

	Even Office Trunk		Odd Office Trunk	
Choice	Lead	JC Relay	Lead	JC Relay
A	EA	0	OA	1
B	EB	0	OB	1
C	EC	0	OC	1
D	ED	0	OD	1
E	EE	8	OE	9

Office Group-1

	Even Office Trunk		Odd Office Trunk	
Choice	Lead	JC Relay	Lead	JC Relay
A	EA	2	OA	3
B	EB	2	OB	3
C	EC	2	OC	3
D	ED	2	OD	3
E	EE	8	OE	9

Office Group-2

	Even Office Trunk		Odd Office Trunk	
Choice	Lead	JC Relay	Lead	JC Relay
A	EA	4	OA	5
B	EB	4	OB	5
C	EC	4	OC	5
D	ED	4	OD	5
E	EE	8	OE	9

Office Group-3

	Even Office Trunk		Odd Office Trunk	
Choice	Lead	JC Relay	Lead	JC Relay
A	EA	6	OA	7
B	EB	6	OB	7
C	EC	6	OC	7
D	ED	6	OD	7
E	EE	8	OE	9

FIGURE No. 17

CBA1-CBA4
CBB1-CBB4

The feature of distributing successive calls over different office junctor choices is used when more than 20 office junctors are available between one choice. A walking circuit is, therefore, provided in the marker (Fig. 17) to care for this condition when required and is included in the circuit wiring by using "Z" wiring and excluded by using "W" wiring.

It is assumed for this description that "Z" wiring is used in figure 17 and that the marker is set for the "A" choice junctors. In this case the CBB1 relay was operated and locked when the JD relay released from the previous call.

When the marker is selected for the next succeeding call, it functions as already described, the AC relay operating the CBC relay. The JD relay in operating operates the CBA1 relay which locks. When the marker finds an idle trunk, one of the EL, OL, ER or OR relays operate and connect ground to one of the leads "E" or "O" depending upon whether the selected trunk is located on the even or odd numbered office frame.

The grounded "E" or "O" lead is connected to the proper JC- relay by the operated CBA1 relay and the combination of the O- and IF- relays operated.

If a channel is found with this choice of office junctors, the circuit functions as in a regular call and disconnects. When the JD relay releases during disconnection, it operates the CBB2 relay which locks and causes the release of the CBB1 relay. The release of the CBB1 relay opens the connection between the "E" and "O" leads and the "EA" and "OA" lead respectively.

When the marker is again selected for the next succeeding call and the JD relay operates, the CBA2 relay operates and locks in the "B" choice and releases the CBA1 relay. The "E" and "O" leads are then connected in the "OB" and "EB" leads of the "B" junctor choice. The CBA3, CBB3, CBA4 and CBB4 relays operate in a like manner in the C and D choices on succeeding calls and then reverts to the CBA1 and CBB1 relays in the A choice.

On an 8 x 8 pattern, the same office junctors are being selected in any of the A to D choices. For this reason, the CB1, CB2, CB3 and CB4 terminals of figure 17 are strapped together, so that whenever the CBB1, CBB2 or CBB3 relay is operated at the start of a call, the CBC relay will operate when the AG relay operates. The CBC relay when operated, will cause the E choice junctors to be selected, if all channels are found busy, whenever the A, B or C choice junctors are tested. This is to prevent the same office junctors from being tested more than once on any one call. The CBC relay is not required on the D choice because the circuit is arranged to progress to the E choice if all channels are found busy in the D choice.

The strapping of the NPO, NP1, NP2, NP3 and NP4 provide a path for operating the BK relay as a check that one of the CBA1 to CBA4 relays are operated for the call.

ALL CHANNELS BUSY - "A", "B", "C" OR "D" CHOICE

OS- 92-1

CHL

On the first, second or third trial call, if an idle trunk is found but all channels between the incoming trunk and the selected outgoing trunk are found busy, the marker releases the selected JC relay and advances to the E choice. The marker then operates the JC relay for the E choice junctors and channels test is made a second time and if an idle channel is found the call proceeds in the regular way.

It is assumed in this case that the call has progressed up to operation of the CHT relay, an idle trunk having been found on the even numbered office frame and the connector has been released in the regular manner. With all channels busy, operation of the CHT relay closes a path through contacts of operated AB or C relays in the channel testing circuits, causing the CHL relay to operate and lock.

When the CHL relay operates, battery is disconnected from the windings of the CH relays. This is done to prevent the selection of a wrong channel. This might otherwise occur if a channel in the group just tested and found busy should become idle, releasing its AB or C relay and causing the corresponding CH relay to operate, while the marker is advancing to test the next choice channels.

CBB5

The operation of the CHL relay causes the CBB5 relay to operate. If the marker is set for the A, B or C choice, the path for operating the CBB5 relay is from ground on the top of No. 2 of CHL, CB lead, break of CBA5 relay, make of either the CBA1, CBA2 or CBA3 relay, make of CBC relay, CBB lead, make of CHL relay, CBB5 lead, to winding of CBB5 relay. If the marker is set for the D choice, the path is through the make of CBA4 relay to the winding of the CBB5 relay.

The operation of the CBB5 relay releases the CBB1, CBB2, CBB3 or CBB4 relay whichever one is operated. It also releases the P- and JC- relays operated followed by the BK, CHT and CHL relays.

CBA5

The release of the CHT relay operates the CBA5 relay, which releases the CBA1, CBA2, CBA3 or CBA4 relay, depending upon which one was operated at the start of the call.

Operation of the CBA5 operates the marker and trunk link JC- relays and the required pattern relay. With the JC relay operated, the "E" test choice of junctors are now connected and the BK relay again operates removing the shunt from the winding of the CHT relay, which starts to operate to test for an idle channel.

If an idle channel is now found in the "E" choice junctors by the operation of a CH- relay, the call then functions the same as a regular call. At the completion of the call, the release of the JD relay causes both the CBA5 and CBB5 relays to release and the CBB1 relay to operate.

ALL CHANNELS BUSY - "E" CHOICE

BE1 & BO1

If all the channels in the E test choice are also found busy, then when the CHT relay again operates, in turn operating the CHL relay, the BE1 relay operates if the EL or ER relay is operated, due to an even trunk having been selected. If an odd trunk was selected for the call, in which case the OL or OR relay is operated, then the CHL relay operating would operate the BO1 relay.

The operation of the BE1 or BO1 relay causes the release of the JC-, P- and K- relays, disconnecting the E choice junctors and wiping out the trunk selection recorded at the beginning of the call.

BE & BO

The BE1 relay operated, operates the BE relay which makes all the even trunks appear busy by operating the associated T- relays. If the BO1 relay is operated, the BO relay operates to make all odd trunks appear busy by operating their associated T- relays. The BE1 or BO1 relay in operating, releases the operated K- relay, in turn releasing the EL, ER, OL or OR relay which allows the MCB relay which was released to reoperate. The BE1 or BO1 relay also releases the operated office link LC relay which opens the check path, releasing the CK relay.

CBL

When the trunk link frame JC- relay releases, it opens the check path for the BK relay which releases, in turn causing the CHT to be driven to its back contact and releasing the CHL relay when its front contact opens. The CHT relay closing its back contact operates the CBL relay due to the BE1 or BO1 relay being operated.

CBH

The operation of the CBL relay releases both the CBA5 and CBB5 relays, which close a circuit to operate the CBH relay at the same time checking for the release of the CBA- and CBB- relays and the CK relay. This path is traced from battery through CBH relay, make CBL, break CBB5, CBB4, CBB3, CBB2, CBB1 and CK relays, make CBL, break CBA1, CBB5 and CBB4 relays to ground on make of JD relay.

The CBH relay in operating operates the CBB1 relay which in turn operates the CBA1 relay from the locking ground of the CBH relay.

PT

When the TKE relay reoperates, it removes the shunting ground from the PT condenser and allows the PT relay to operate.

The operation of the PT relay is condenser timed as previously described. The circuit advances from this point as in a regular call for selection of a trunk except that due to the above operations the trunks on the office frame previously used have been made to appear busy and, therefore, a trunk on the other frame is selected. Transferring over to the other office frame provides a new selection of JC relays and office junctors in each of the "A" and "E" choices.

If an idle trunk and channel are found, the call is completed as in regular operation.

JUNCTOR PATTERNS (20 X 20) OS- 92-6 TO 96-12

As previously stated the junctors on a trunk link frame are equally divided over all the office link frames. The number of junctors connecting any trunk link frame to any office link frame is, therefore, obtained by dividing 200 by whichever is larger, the number of trunk or office link frames.

When a 20 x 20 installation (20 trunk link and 20 office link frames) is being considered, the division of district junctors is such that each trunk link frame will have 10 junctors to each office link frame.

As there are not enough junctors to form more than one test group, figure 17 and "AJ" equipment is not required and "W" wiring is installed.

It can also be seen that the one test group of junctors will not be a complete test group, there being only 10 junctors connecting any trunk link frame to any office link frame. As the marker is equipped to test 20 channels at a time, it is necessary that the 10 blank channels be made to appear busy.

Two pattern relays are provided to make the blank channels appear busy. Each pattern relay will busy 10 channel positions by operating the corresponding C- relays. The pattern JP- relay to operate is under control of the operated IFO to 19 relay and the operated EL, OL, ER or OR relay. This is due to the fact that all odd trunk link frames require the JP1 relay when an even office link is being used and the JPO relay when an odd office link is required. Even trunk link frames require the reverse of the above plan.

The ten junctors in any group will be reduced to five if the outgoing trunk selected should be on a split level. In this case the operation of the SPL or SPR relay will blank out five left or right channels respectively.

The 10 junctors that connect the particular trunk link frame to the office link on which the selected outgoing trunk appears, are submitted to the marker for test by the trunk link JC- relay.

The marker JC- relay to operate is controlled by the operated O- relay and the operated EL, OL, ER or OR relay. This in turn operates a JC- relay in the trunk link as follows:

Marker JC-	Even Trunk Link JC-	Odd Trunk Link JC-
JC0	JC0	JC1
JC1	JC1	JC0
JC2	JC2	JC3
JC3	JC3	JC2
-	-	-
JC18	JC18	JC19
JC19	JC19	JC18

This alternation of JC- relay numbers is done in order to standardize the manufacture of trunk link frames. It is not required to specify whether the frame is to be an odd or even frame. The JC- lead multiple between trunk link frames compensates for the slip of JC- relays between frames.

ALL CHANNELS BUSY (20 X 20)

It will be assumed that the first outgoing trunk selected was on an even numbered office link frame and that the selected outgoing trunk is in a split level. The marker SPE and SPO relays are operated in turn causing the SPL or SPR relay to operate and busy out by operating the C- relays, five of the 10 junctors which were submitted for test by the trunk link JC- relay.

The operated JP- relay busied out the 10 channel positions which were blank by operating the associated C- relays. It will be found that some of the C-relays are operated by both the JP- and SPL or SPR relays. Any other C- relays which are also operated in the remaining 5 channels are being operated by legitimate traffic busy conditions.

The operation of CHT relay starts channel test. With all channels busy, as indicated by an operated AB- or C- relay in each of the 20 channel test circuits, Fig. 15, the CHT relay in operating causes the CHL relay to operate.

CHL

In operating the CHL relay disconnects the operating battery of the CH- relays. This prevents the selection of a channel once an all channels busy condition has been registered. (Operation of CHL relay.)

BO1 or BE1

One of these relays operates due to the operation of the CHL relay and one of the EL, OL, ER or OR relays operated. The operated relay opens the operating battery of the associated K- relays releasing the operated K- relay.

JC-

The marker JC- relay releases due to the operation of the BE1 relay, in turn, releasing the trunk link JC- relay. This disconnects the 10 junctors from the marker releasing any AB- relays which were operated from busy junctors.

P-

The pattern relay is released by the operated BE1 relay because when a trunk on the odd office link is selected the other pattern will be required. Any C- relays which were held operated by the P- relay release.

BE or BO

In this case the BE relay operates due to the BE1 being operated. The 20 T- relays associated with the 20 trunks appearing on the even office link frame operate. This will cause those trunks to test busy and a trunk on the odd office link frame to be selected if available when the trunks are retested.

K- RELEASE

The K- relay is released in order to operate an odd numbered K- relay for the second outgoing trunk. The release of the K- relay causes the EL or ER relay to release and in turn the SPL or SPR relay. The release of the SPL or SPR relay releases any C- relays which were operated by grounds on the SPL or SPR relay contacts. This is necessary because the next group of 10 junctors submitted may require the use of these C- relays.

LC- (OFFICE LINK)

The office link LC- relay is released by the operation of the BE1 relay in order to disconnect the 20 "C" links which were involved in the first channel test from the marker. This is done in preparation for submitting the 20 new "C" links associated with the trunk on the odd office link when it is selected. This also releases C- relays which were held operated by busy "C" links.

BK

The BK relay released due to the release of the trunk link JC- relay. The BK operating path is also opened at this time by the release of the SPL or SPR relay.

TKE

The TKE relay operates due to the release of the BK relay and the K- relay which was operated. This removes the ground which is holding the PT relay on its back contact allowing the PT relay to operate to its front contact after the PT condenser has charged. The delay introduced by the charging PT condenser is for the purpose of providing time for all T- relayswhich should operate to do so. If a trunk is available a K- relay will operate. From this point the call proceeds as for a regular call.

ALL TRUNKS BUSY ON SECOND TEST

TBL & CRL

On first and second trial calls if all channels are found busy as above, and if on the second test all trunks are found busy on the remaining frame, a trouble release signal is sent to the sender. This signal is sent by way of the incoming trunk and sender link and causes the sender to make another trial. In this case a regular release signal by way of the connector has already been sent to the sender.

On third trial calls under these conditions, a trouble release signal is sent and the sender will dispose of the call without further aid from a marker.

When the PT relay operates for its second test, all T- relays being operated, the TBL relay operates in turn operating the CRL relay. The CRL relay causes the TRL lead to be grounded and operates the RL relay for marker release.

Under this condition, grounding the TRL lead starts to operate one of the TR- relays in the sender and at the same time the RL relay in the marker. The RL relay is made slow operate to insure the operation of the sender TR- relay before ground is removed from the TRL lead.

The CRL relay when operated, connects ground to an OF terminal on the operated O- relay and an OF terminal on the operated IF- relay, scoring an overflow traffic register in both cases.

ALL CHANNELS BUSY ON SECOND TEST OF "A" AND "E" CHOICE

CHL

If all channels are found busy in one of the A to D choices, followed by all channels busy in the E choice as described above, and if on the second test an idle trunk is found and then when the channels are tested for the third time, they are all found busy, the CHT relay in operating releases the CBL relay and operates the CHL relay.

The CHL relay operating causes the marker to advance to the E choice for the selection of a channel as previously described. If an idle channel is found in the E choice junctors, the circuit proceeds to set the connection up in a normal manner.

If when the CHT relay operates for the fourth time in testing the "E" choice for the second time, and all channels are found busy, the CRL relay is operated due to the CBH relay being up with the CBA5 relay operated. This completes the test of all the available channels and the marker must now give the sender a trouble release signal in order that the marker can be released and the sender can try to set the connection up with another marker.

The CRL relay operated causes the marker to function the same as when all trunks are found busy on a second test.

ALL CHANNELS BUSY ON SECOND TEST

When the CHT relay operates for the selection of a channel on the second test and all channels are busy as indicated by an operated AB- or C- relay in each of the 20 channel test circuits the marker proceeds as follows:

CHL

The CHL relay operates due to an AB- or C- relay being operated for each channel.

CRL

The CRL relay operates due to the fact that the CBH relay is held operated from the first test all channels busy condition. The operations continue from this point as for All Trunks Busy on Second Test.

DOUBLE CONNECTION TEST

OS- 84

The DT1, DT2 and DT3 relays are provided to detect double connections on trunks that are used by one group of markers in common with panel equipment. The DT4 and DT5 relays are provided for the purpose of releasing a selected trunk involved in a double connection after a channel has been selected, also releasing the selected channel and starting anew on selecting a trunk.

DT1, DT2 & DT3

As indicated for a regular call, the DT2 relay operates when the ST1 relay operates, in turn, operating the DT1 relay. When the EL, OL, ER or OR relay operates, the DT2 relay releases, leaving the winding of the DT1 relay connected to the S1 lead of the selected trunk and removing the make busy ground.

If the S1 lead of the trunk is not falsely grounded, and if the trunk has not been seized and made busy simultaneously by a panel selector, the DT1 relay releases and again makes the trunk busy.

If there is a false ground or a make busy ground on the S1 lead of the trunk, however, it locks the DT1 relay. Release of the DT2 relay in this case causes the DT3 relay to operate and lock.

The call proceeds through channel test up to the release of the HMT1 relay. With the DT1 and DT3 relays operated, however, the path to operate the C relay and the office link secondary hold magnet and the path to operate the A relay and the trunk link primary hold magnet are both opened at the contacts of the DT3 relay.

DT4

Release of the HMT1 relay and with the DT3 relay operated closes a path to operate the DT4 relay. The DT4 relay opens the battery supply for the K- and CH- relays, thereby releasing the K- relay for the selected trunk and the CH- relay for the selected channel.

CH-

The release of the CH- relay reoperates the CHE relay, which reoperates the CHE1 and CHE2 relays, causing the HMT relay to be driven to its back contact in preparation for the reselection of an idle channel.

K-

When the K- relay releases for the selected trunk, it allows the P- and T- relays to operate from the busy ground on the S1 lead which was applied by the panel office.

The K- relay also causes a series of releases in the marker and trunk link, allowing the BK relay to release. The BK relay causes the CHT relay to be driven to its back contact.

DT5

When the CHT relay closes its back contact, the DT5 relay operates and reconnects the battery to the windings of the K- and CH- relays.

PT

Whenever the TKE relay releases, after the PT relay has operated, the PT condenser is short-circuited and the secondary winding of the PT relay energized driving the PT relay again to its back contact. When the BK relay releases, the TKE relay reoperates and allows the PT relay to be condenser timed. When the PT relay operates, a new trunk is selected for the call.

If no double connection is encountered on the second trunk, the DT1 relay releases, upon the release of the DT2 relay and the call continues as in a regular call selecting a new channel.

ALL TRUNKS BUSY ON SECOND TEST (AFTER DOUBLE CONNECTION)

CRL

Should all trunks be found busy when the marker proceeds to select the second trunk on a double connection, the TBL relay in operating, operates the CRL relay due to the DT4 relay operated.

The CRL relay operated, grounds the TRL lead to the sender and operates the RL relay for release of the marker. The overflow traffic register at both the O- and IF- relays are operated. The sender receiving ground on the TRL lead proceeds to make a new trial.

DOUBLE CONNECTION ON SECOND TEST (AFTER DOUBLE CONNECTION)

RL

If after a double connection, a second trunk is selected but the marker encounters a second double connection, the DT1, DT2 and DT3 relays function as already described. The call continues to function up to the release of the HMT1 relay which due to the DT5 relay operated, the TRL lead to trunk link is grounded and the RL relay operated for release of the marker. The sender will proceed to make a new trial.

SENDER TRUNK TEST FAILURE

Note No. 131
OS- 96
TGF

When a connection has been set up and the marker released, the tandem sender will proceed to test the trunk to the terminating office for continuity. If the trunk test is not completed satisfactorily after a time interval, the sender will call again for a marker to obtain a trouble indicator record which will aid the maintenance force in locating open trunks or channels.

On this type of call the sender will transmit the regular code and trunk frame information as on the regular call which caused the trunk guard failure. In addition, the sender grounds the TGF lead to the marker operating the TGF relay.

XR1

The TGF relay operated, operates the XR1 relay which opens the circuit to office link frame ST terminal at the operated route relay, preventing the marker from attempting to set up a connection.

XX1

The SR1 relay will operate the XX1 relay, which will in turn operate the DL relay. The DL relay operated, connects resistance battery to the TIA lead to the trouble indicator frame and operates the TR relay. The TR relay calls in the trouble indicator circuit, as described later.

After the trouble indicator has taken a record it will operate the TIB relay which grounds the TRL lead to the sender which will cause the marker to be released. The sender will then make another attempt with the marker but will not on this attempt ground the TGF lead. The marker will then proceed to set the connection up to a regular trunk, reversing the order of trunk testing and shifting the channels start point in order to avoid, if possible, the reselection of the trunk or channel which was found open. The sender after the second attempt will usually be able to set the connection up to the desired destination.

In case of a trunk guard failure on a large trunk group, that is, a trunk group subdivided into two or three subgroups, the trouble indicator record obtained may not indicate the particular subgroup in which the open trunk is located due to the setting of the GZ and GW relays. Therefore, on these large trunk groups, all of the trunks for the particular code must be tested and not just those indicated by the trouble indicator circuit.

If under this condition, the trouble indicator is busy with another marker, at the time this call is being attempted, the TIB relay would be operated. When the TR relay operates to call in the trouble indicator with the TIB relay up, the RL relay is operated and ground is connected to the TRL lead to the sender for release.

TROUBLE DETECTING RELAYS

OS- 96, 97-2, 87

There are numerous X- relays provided to furnish means for detecting false grounds on many of the leads over which connection is made to the associated circuits. These relays are connected when the circuit is normal as well as when busy in service, except of course, on the leads that are actually in use. The operation of any of these X- relays, whether the circuit is busy in service or not will cause the operation of either the XX1 or XX2 or DL relay. The XX1 relay, in general, is operated if a trouble is encountered on the leads that are used during the decoding stage, while the XX2 relay is operated if a trouble occurs on leads that are used during the marker stage.

XX1

If the XX1 relay operates due to closure of any of the paths described above, it locks, connects grounds to operate the CBR and CBS relays, connects ground to start the timing if not already in operation and opens the RL lead to the marker connector.

If the marker is busy in service, the call is blocked. The RL lead being opened prevents the transmission of a regular release signal if one has not already been given. Whether in service or not, the closure of ground to the CBR and CBS relays and to the time measure relays insures that the marker circuit is held busy and that it times out. This operates the trouble alarm and calls in the trouble indicator for a record as described later.

XCR

The marginal XCR relay is wired in parallel with the windings of the CRP and CRS relays to detect when the primary and secondary windings of a CR- relay are both energized. This may be due to error in cross-connections or if a false ground or a cross should occur causing any two windings of the CR- relays to be energized. The XCR relay in operating operates the XX1 relay.

XCL

The marginal XCL relay is wired in parallel with the CL- relays to detect false conditions as explained for the XCR relay. The XCL relay in operating, operates the XX1 relay.

XR & XR1

The marginal XR relay is in series with the windings of the R1 and R2 relays to detect when two route relays in parallel are energized. When the XR relay operates, it operates the XR1 relay, which in turn operates the XX1 relay.

Should both the TR1 and TR2 relays be operated on one call, a path is closed to operate the XR1 relay, which operates the XX1 relay.

XT

The transmitting leads are connected through normal contacts of the numbered transmitting relays to the winding of the XT relay. A false ground on any of these leads with the circuit normal, or a false ground on a lead not used during a call, or a short circuit between a lead used for a call and one not used, consequently causes the XT relay to operate, in turn operating the XT1 relay. The XT1 relay operates the XX1 relay.

OS- 87, 96, 97-2

XX2

The XOF, XTL, XSS, XGS and XGE marginal trouble detecting relays are associated with groups of relays where a selection one relay is made. If more than one relay in a group operates, the associated X relay operates, in turn operating the XX2 relay.

The XSL, XSM, XK, XTL1, XTL2, XTL3, XBC, XCH, XLC, XLC1, XS and XS1 trouble detecting relays are associated with leads to other frames, being connected to these leads in which they do not cause interference. Any one of these relays in operating, due to a false ground or a cross on the leads, operates the XX2 relay.

The XX2 relay operated opens the LS leads to the trunk link and office link frames, opens the RL lead and the operating path of the MRL relay holds the marker busy and connects ground to the time measure circuit as for the XX1 relay and operates the DL relay.

The DL relay operated connects resistance battery to the TIA lead to the trouble indicator frame and operates the TR relay. The TR relay calls in the trouble indicator circuit as described later.

OS- 96, 97-1

DL

The following X- relays operate the DL relay direct and independent of the XX1 and XX2 relays. The DL relay operated connects ground to the TIA lead and operates the TR relay as already described.

XRL

The XRL relay checks the RL, RO and TRL leads of the connector and the TRL lead of the trunk link for false grounds while the RX relay is normal.

If it operates due to a false ground on one of these leads, it locks, connects ground to hold the marker busy, and connects ground to start the time measure if not already in operation. The trouble indicator is called in by the operation of the DL relay as before.

XIF1

The XIF1 relay checks for premature ground on the SB lead of the office link frame and premature ground on the ST lead of the trunk link frame with the STX relay normal. If it operates due to a false ground on one of these leads, it operates the DL relay which functions as already described.

XIF

Should some false, short or trouble ground cause two of the F-0 to F-19 leads to be grounded at the same time energizing two IF-0 to IF-19 relays in parallel, the XIF relay will be operated in series with the locking windings of the two relays. The XIF relay in operating prevents the trunk link frame MP relay from operating over the SB lead from the office link frames and thereby cause a time-out in .4 of a second by the TM relay which operates the DL relay as explained later.

XSM1 & XSM2

When the marker SM relay operates, it operates the SM1 relay, which energizes the XSM1 relay driving it to its back contact. When the CHE2 relay releases for the channel selection, battery through the primary winding of the XSM1 relay is supplied to operate one of the 2 to 9 primary select magnets of the trunk link frame. If two of these select magnets have ground connected to them due to a trouble, the current produced in the primary winding of the XSM1 relay will be sufficient to operate the relay. The XSM1 relay operates the XSM2 relay which in turn operates the DL relay for calling in the trouble indicator.

CROSSED JC LEADS

The marker circuit is arranged to prevent the operation of any trunk link and connector circuit JC relays in case of the JC lead required for the call is crossed with some other JC lead.

As previously described for a regular call after the selection of a trunk, a marker circuit JC relay is operated corresponding to the office frame on which the selected trunk is located. This relay in turn connects battery to a JC lead to the trunk link and connector circuit to operate a corresponding JC relay on the trunk link frame. In order to prevent the operation of two or more relays in the trunk link and connector circuit and the consequent connection to the marker for test of two or more groups of office junctor circuits, the marker connects ground through normal contacts of its JC relay to all the JC leads which are not required for a call.

Consequently if the lead that is used for a call is crossed with any lead that is not used, the direct ground connection on the latter short-circuits the operating battery for the trunk link JC relays and none of them operate. This causes the marker to time-out as described later and call in the trouble indicator.

SHORT CONDENSER - TIMED TIME-OUT

OS- 86-3

TM

Should a marker block after seizing an office or trunk link frame, any other marker which is waiting for that frame will block too, and both markers will start timing. If the waiting marker should time-out first, it would seize the trouble indicator and make it busy before the marker which is in trouble can record its trouble.

In order to avoid this condition and also to save marker holding time when such troubles occur, the condenser timed TM relay is provided. This relay operates in about 0.4 second, allowing this length of time for certain functions and timing the marker out if the functions are not completed within this interval.

When the ST1 and ST2 relays operate the primary and secondary windings of the TM relay are both energized. The secondary winding being the stronger of the two and being energized in the released direction causes the relay to be driven to its back contact. At this time the TM condenser is also short-circuited.

OCB

As soon as the marker seizes an office link frame, the OCB relay operates removing the short circuit from the TM condenser and opens the energizing circuit for the secondary winding of the TM relay. However, the TM relay does not operate immediately because current continues to flow through the secondary winding until the large TM condenser becomes charged. In the meantime, the marker should pick a trunk causing the CK and BK relays to operate.

In case the marker finds all trunks busy on the office frames, it releases these frames, dropping relay OCB which discharges the TM condenser. Then if another pair of office frames are seized, the OCB relay reoperates and starts the TM relay timing anew.

SPT

The operation of the BK relay closes ground through a front contact of the SPT relay to reenergize the secondary winding of the TM relay and discharge the TM condenser. The operation of the BK relay also releases the SPT relay but this release is delayed slightly by a shunt on the winding of the SPT relay by the EA and EB resistances in order to allow sufficient time to discharge the TM condenser.

CB LEAD - TRUNK LINK

In case the trunk frame has not been seized by the time the relay CK operates, then the BK relay will not operate immediately to recycle the TM relay timing. However, with relay CK up, the TM condenser is connected through a back contact of relay TMS and a front contact of the IF- relay operated to the CB lead to the trunk link frame wanted. If the trunk link frame is busy with any marker the CB lead is grounded, discharging the TM condenser. Then, as soon as this marker seizes the trunk link frame the TMS relay operates, removing ground from the TM condenser to start timing again.

MRL

The recycling of the TM relay and TM condenser after the TMS relay operates is to time for the release of the marker.

The marker then proceeds to test for a channel, set up the connection and release, which should occur before the TM relay operates. Upon completion of the marker operation, the MRL relay operates and discharges the TM condenser, preventing any further operation of the TM relay.

In case all channels of the first choice test busy, the marker will test other choices, in which case the BK relay is released each time the trunk link JC- relay releases. The release of the BK operates the SPT and then when the BK reoperates, ground is connected to the TM condenser during the release time of SPT, recycling the TM relay timing.

From the above, it is evident that relay TM allows about 0.4 second for each test of outgoing trunks and for each test of channels and that this timing is stopped while the marker is waiting for a busy office or trunk link frame. In case any test of trunks or channels is not completed within the time allowed, the TM relay finally operates, causing the operation of relay DL which calls in the trouble indicator.

TIMING CIRCUIT - SHORT TIME-OUT

OS- 97-1

The TM interrupter and the timing relays TMS, TMS1, TMS2, TMW, TMZ, TM1 and TM-4 to TM-7 are provided for calling in the trouble indicator and releasing the marker and associated circuits if the progress of the circuit should be stopped due to trouble.

The short time-out is divided into three stages. The first stage covers the period from seizure of the marker circuit to the completion of registration of the code, trunk link frame, etc., information having been properly received from the sender. The time allowed for these functions is from approximately .535 seconds minimum to 1.595 seconds maximum, depending upon the position of the interrupter at the time the circuit is seized.

If no trouble is encountered during the first stage, the time operations are continued and additional 3.18 seconds being allowed for the circuit to progress up to operation of the DK relay.

This time-out period is normally 3.715 seconds minimum to 4.775 seconds maximum. This constitutes the second stage.

When the DK relay operates any remaining time for the second stage is cancelled and the third stage is started. A period of approximately 1.595 seconds minimum to 2.655 seconds maximum is allowed for the circuit to complete the call and release after the DK relay operates.

These time intervals are considerably greater than the marker requires to perform its functions if no trouble is encountered.

When the circuit times out in any one of the three stages, the trouble indicator circuit is called in, if available, to take a record of the call. The marker and associated circuits are then released. If the trouble indicator is found busy the TRL lead is grounded and the RL relay operated immediately disconnecting the marker and associated equipment without recording the trouble.

Should some trouble prevent the trouble indicator from being called in, the marker continues to count time for a fourth stage of an additional 3.715 seconds, if the marker trouble occurred during the first stage or 1.060 seconds for the second and third stages, after which a trouble release signal is given to the sender and the marker is restored to normal.

On overlapped calls, the TM lead, which is the control lead for the short time-out circuit, may be continuously grounded for several calls. During the busy hour it is quite likely to be continuously grounded for periods longer than the maximum short time-out period. The short time-out circuit is consequently arranged to recycle itself on the completion of each call so that it will not time-out, even though the TM lead is continuously grounded, provided that each call progresses through the marker in a normal time.

As previously described, the marker connector circuit, when it operates its marker multi-contact relays, connects ground to the TM lead to the marker. The connector circuit also releases the marker control DA1 and DA2 relays which close additional grounds to this lead.

TMS1

When ground is connected to the TM lead and assuming that there is not a call in the marker stage, the TMS1 relay operates and locks at the same time checking to see that the TMW, TM5, TM1 and TMS2 relays are normal. The TMS1 relay grounds the TM interrupter which closes the B contact for .525 second and is open for .535 second because the F contact is not used.

TMW & TMZ

When the TM interrupter is grounded with the B contact closed or when it does close the TMW relay operates and locks. The winding of the TMZ relay is shunted, however, and will not operate until the B contact of the interrupter opens at which time the TMZ relay operates.

When the B contact of the TM interrupter again closes, the TMW relay is shunted and will release but the TMZ relay will stay operated until the TM interrupter contacts open when it releases. The next closure of the TM interrupter contact operates the TMW relay as in the beginning and the cycle repeats itself as long as the TMS1 relay remains operated.

FIRST STAGE

TM1

When the TMW relay releases on the start of the second cycle, the TM1 relay operates. It can be seen that the minimum amount of time that must elapse before this relay can operate is .535 second or a maximum of 1.595 seconds. If when the TM1 relay operates the R1 or R2 relay has not been operated, which it will when the code and other information has been properly received from the sender, the marker DL relay operates. If the DL relay operates, it calls in the trouble indicator circuit, if available, to take a record of the call and release the circuits as described later.

If the DL relay operates and the trouble indicator is busy, the TR relay operates from the DL relay and the TIB relay is up from the busy trouble indicator. This combination of operated relays ground the TRL lead and operates the RL relay causing the marker and associated circuits to release immediately.

The DL relay does not operate if registration has been properly completed. In this case the circuit continues to count time.

TM4

At the start of the third cycle of the TM interrupter when the TMW relay operates, the TM4 relay operates through the contacts of the TM1 relay operated. The function of the TM4 relay is to prepare a path for operating the TM5 relay later.

TM5

At the start of the fourth cycle of the TM interrupter when the TMW relay is released, the TM5 relay operates through the contacts of the TM4 relay operated and prepares the path for operating the TM6 relay later.

SECOND STAGE

TM6

When the TMW relay operates at the start of the fifth cycle of the TM interrupter, the TM6 relay operates. It can be seen that the minimum amount of time that must elapse before this relay operates is 3.715 seconds or a maximum of 4.775 seconds. If the DK relay has not been operated by the time the TM6 relay operates, this second stage time is not cancelled and, therefore, the TM6 relay operates the DL relay. If the DL relay operates, it calls in the trouble indicator circuit, if available, to take a record of the call and release the circuits, as described later.

If the DL relay operates and the trouble indicator is busy, a trouble release signal is sent to the sender and the marker restores to normal as already described.

If the DK relay operates within the allowed time and the circuit consequently does not time-out as above, operation of the DK relay releases the TMS1 relay at an earlier point. The TMS1 relay released, releases the TM1 relay which releases any other TM relays that may be operated, cancelling any remaining time for the second stage.

Operation of the DK relay within the allowed time also starts the third stage of the time measure.

THIRD STAGE

TMS2

When the trunk link frame is connected, the DK relay in operating, operates the TMS relay and releases the TMS1 relay and all timing relays operated. A path is then closed for operating the TMS2 relay which regrounds the TM interrupter for starting the third stage of timing.

This path is traced through normal contacts of the time measure relays as above to insure that these relays are not left operated from the second stage when the third stage is started. When the CK relay operates, it closes a locking path for the TMS relay so that the time measure will continue after the DK relay releases.

The TMS2 relay, when operated, operates the TM4 relay which will cancel two of the TM interrupter cycles as used in the first and second stages of timing.

TM5

At the start of the second cycle of the TM interrupter, when the TMW relay releases, the TM5 relay operates due to the TM4 relay having been operated at the start of the third stage.

TM6

At the start of the third cycle of the TM interrupter, when the TMW relay operates, the TM6 relay operates. It can be seen that since only three cycles of the TM interrupter are necessary to operate the TM6 relay, the minimum amount of time that must elapse is 1.595 seconds or a maximum of 2.655 seconds.

If the marker has not completed its marker stage operation by the time the TM6 relay operates, the DL relay is operated. If the DL relay operates, it functions as before to call in the trouble indicator circuit, if available. If the trouble indicator circuit is busy a trouble release signal is sent to the sender and the marker restores to normal as already described.

If the circuit completes the call and restores to normal within the time allowed after operation of the DK relay and consequently does not time-out as above, the TMS2 relay releases when the ST-1 relay releases. Release of the TMS2 relay releases any other TM relays that may be operated.

If the TM lead is kept grounded due to an overlapped call, the TMS-1 relay reoperates when the TMS2 relay releases in order to start the first stage of the time measure for the next call. The operating path for the TMS1 relay is traced through normal contacts of the DK, TMS2, TM1, TM5, TMZ and TMW relays to insure that these relays release before another cycle of timing is started.

FOURTH STAGE

TM7

If at any time the DL relay operates and the trouble indicator circuit cannot be called in due to some condition other than a normal busy or should it be impossible to send a trouble release signal to the sender when the trouble indicator is normally busy, the timing circuit continues to time. This timing may continue from the first or second stages after the DL relay operates, either of which will reach the operation of the TM6 relay as described above.

With the TM6 relay operated for this failure, the TM interrupter continues to time for 1.060 seconds. When the TMW relay releases following the operation of the TM6 relay, a path is closed to operate the TM7 relay.

The operation of the TM7 relay opens the DK lead to the trunk link frame and removes battery from the ST lead to the office link and connector circuit causing the associated office link frames to restore to normal, in turn, releasing the trunk link frame. The TM7 relay also operates the RL relay.

TM10

The operation of the TM7 relay operates the TM10 relay, which connects ground to the TAP and MB leads to the trouble indicator frame, and grounds the TA lead to the miscellaneous circuit for the marker frame. These leads grounded actuate an alarm.

The TM10 relay also connects ground to the TRL lead to the marker connector and to the TRL lead to the trunk link and connector circuit. The trouble release signal is sent through the connector circuit if it has not already been released. The sender then releases the connector and makes another trial except for third trial calls.

If the marker connector has already been released, the trouble release signal is sent by way of the incoming trunk and sender link. However, since the TM7 relay opens the ST lead to the office link and connector circuit causing the office link and trunk link frames to release, the trouble release ground connected by the TM10 relay may not be connected long enough to register in the sender before the TRL lead is opened by the release of the trunk link and connector circuit. If this should happen the sender would be stuck and would time-out. It is thought better to do this, however, than to risk the possibility of not releasing the trunk link and office line in case some abnormal condition should prevent the operation of the TM6 relay from causing the marker to restore to normal.

MRL

The RL relay operated, with the RX relay up, operates the MRL relay. Should the marker be in a setting where the RX relay is released, the operation of the MRL relay is delayed until the trunk link frame is released at which time the release of the AK relay operates the RX relay. The MRL relay operated causes the marker to restore as previously described. When ground is removed from the TM lead by the marker connector circuit and with the ST1, XRL, XX1 and XX2 relays in the marker normal, the TMS2 and TM7 relays release. Release of the TMS2 relay causes the TM4, TM5 and TM6 relays to release. The TM7 relay released, removes ground from the TRL lead.

The TM10 relay is locked under control of the AR key in the miscellaneous alarm circuit for tandem marker frame. When operated the TM10 relay releases removing ground from the alarm leads.

TIMING CIRCUIT - LONG TIME-OUT

Note No. 137
OS- 82
DB INTERRUPTER

The DB interrupter and the TM8, TM8A, TM8B, TM8C, TM9 and TMS relays are provided for sounding an alarm and releasing the associated circuits if some trouble should occur that would prevent the short time-out relays from functioning or if the DB lead should become permanently grounded and thus keep the marker out of service. The time-out period in this case is from 12 to 19 seconds, depending upon the position of the interrupter at the time that ground is connected to the DB lead.

The DB interrupter closes its B contact for .93 second, then opens the B contact and 5.0 seconds later closes the F contact for .93 second, then opens the F contact and .14 seconds later, again closes the B contact for a new cycle.

TM8, TM8B, TM8C & TM9

When a call starts and the DB interrupter is grounded, the TM8 relay operates and locks immediately if the B contact is closed or when the B contact does close for the first time. When the F contact closes, the TM8B relay operates and locks and when the B contact closes for the second time, the TM8C relay operates and locks. When the F contact closes for the second time, the TM9 relay operates.

TM10

The TM9 relay operated, operates the TM10 relay which grounds TAP, MB, TA and TRL leads and operates the MRL relay as already described for the short time-out.

The above operations assume, of course, that the DB lead was continuously grounded and that the TMS relay was not operated from the DK relay or after this that the TMS relay did not release either due to setting up the connection and releasing the trunk link or because the short time-out failed to cause the frame to be released.

TM8A

When the DK relay operates from the trunk link frame being connected, the TMS relay operates. This opens the DB lead and connects direct ground to the DB interrupter. The TM8, TM8B and TM8C relays, if operated, will be released. With the TMS relay operated and the TM8 and TM8B relays released, when the B contact of the DB interrupter closes, the TM8A relay operates and locks. This arrangement recycles the long time as already described when the call has advanced to the marker stage.

The reason for opening the DB lead and connecting ground to the DB interrupter as has been described is to continue the long time-out circuit even though there is not another overlapping call waiting to be served by the marker and, therefore, the DB lead might not be grounded after the marker connector released. Without this arrangement and should the short time-out circuit fail, the marker could not time-out.

If when the TM9 relay operates, should the office and district link frames be connected, the office start lead is opened releasing both these frames. The locking circuit for the ST5 relay is also opened releasing this relay if operated.

As already described the TRL lead is grounded through the marker connector and through the trunk link when the TM9 relay operates. This may give two senders a trouble release if there is a call in the decoder stage and another in the marker stage.

When the call has been set up and the CK relay has released the TMS relay is released and the TM8A relay, if operated, also releases; then if the DB lead is still grounded the timing starts again for operating the TM8 relay as already described.

TRUNK LINK AND CONNECTOR CIRCUIT

SPECIAL CONDITIONS

REMOVING A PRIMARY SWITCH FROM SERVICE

In order to remove a trunk link primary switch from service, each of the sixteen incoming trunk circuits terminating at the switch must be made busy at the O.G.T. board of the distant offices.

REMOVING A SECONDARY SWITCH FROM SERVICE

Each trunk link and connector frame is equipped with ten MB jacks, designated 0 to 9 used for making the corresponding secondary switches busy. Insertion of a plug with the tip, ring and sleeve strapped in one of these jacks opens the SSA or SSB lead from the ten select magnets of the corresponding secondary switch, opens the LS leads of the twenty links which terminate at this switch and connects ground to these leads toward the marker.

The left and right LS leads at any one of these MB jacks have the same numerical designations as the jack and the associated secondary switch. These leads are strapped at corresponding contacts of the ten LC relays for association with the primary switch verticals in each switch of the same number as the secondary switch involved. The SSA or SSB lead for the ten secondary select magnets also has the same numerical designation and is strapped at the LC relays.

The removal of a secondary switch from service affects only two links in each primary switch on any one call, these being the left and right links of the same number as the secondary switch.

MARKER LOCKOUT - TRUNK LINK FRAMES

OS- 91-5
CH

As described for a regular call there is an MP relay in the trunk link and connector circuit for each marker. These relays are wired in a chain circuit for preference in case of simultaneous calls from two or more markers and to prevent double connections.

Each trunk link and connector circuit also includes a corresponding set of E relays wired to perform the same functions as the MP relays. The circuit is arranged for automatic throw-over to the E relays if trouble should develop in the MP relays to prevent delay in the markers.

With all of the MP relays normal, the windings of the CH relay are energized from ground through the two chain circuits formed by normal contacts of the MP relays. Under these conditions the CH relay does not operate as it is differential. It operates only when one of its inductive windings is energized and not the other one which would occur if one of the chain circuits remained open with the other one closed.

If one of the ground chains should be opened due to a trouble with the MP relay normal, or if an MP relay should operate and open only one of the chains, the CH relay operates. The CH relay is slow operate to prevent its operation if one ground chain should be opened slightly before the other one is opened in regular operation.

TR-1 to TR-5

The CH relay operated causes the TR1 and TR2 relays and the TR-3 to TR-5 relays, if required, to operate and transfer the markers to the E relays. The TR1 relay connects ground to the CH lead to the floor alarm frame for giving an alarm. The TR2 relay causes the CH lamp associated with the trunk link frame to light and transfers the windings of the CH relay to the E relay chains. This causes the CH relay to release as both windings are energized.

The marker circuits can now continue to connect to the trunk link frame using the E relays. The alarm may be discontinued by operation of the locking type SA key.

If the chain circuits should fail while the E relays are being used, the CH relay would operate as before and release the TR1 relay. This, in turn, would release the TR-2 to TR-5 relays, transferring the ST, MC and DK leads back to the MP relay, giving the alarm and lighting the CH lamp. In this case, the alarm may be discontinued by releasing the SA key which removes ground from the CH lead and extinguishes the CH lamp.

With either the MP relays or the E relays in use and with the SA key respectively normal or operated so that the alarm is not in operation, manual throwover to the other set of relays may be accomplished by momentary operation of the non-locking MTR key followed by operation or release of the SA key as required. The MTR key causes the CH relay to operate by opening the circuit through one of its windings. This causes the TR relays to operate or release as before, transferring the leads and giving the alarm. Subsequent operation or release of the SA key stops the alarm.

OFFICE LINK AND CONNECTOR CIRCUIT

SPECIAL CONDITIONS

REMOVING A PRIMARY SWITCH FROM SERVICE

Each office link and connector frame is equipped with ten PMB jacks, designated 0 to 9, used for making the corresponding primary switches busy. Insertion of a plug with the tip, ring and sleeve strapped in one of these jacks opens the PA or PB lead from the ten select magnets of the corresponding primary switch opens the LS leads of the twenty links connected to this switch and connects ground to these leads toward the marker.

The left and right LS leads at any one of these PMB jacks have the same numerical designation as the jack and the associated primary switch. These leads are strapped at corresponding contacts of the ten LC relays for association with the horizontals of the primary switch. The PA or PB lead for the ten primary select magnets also has the same numerical designation and is strapped at the LC relays.

REMOVING A SECONDARY SWITCH FROM SERVICE

Ten SMB jacks are provided for each office link frame and for each office extension frame for making the secondary switches busy. Insertion of a plug with the tip, ring and sleeve strapped in one of these jacks opens one lead, either from the SA or SB, or the EA or EB lead of the ten select magnets of the corresponding secondary or extension switch, opens the S1 leads of the outgoing trunks connected to this switch and connects ground to these leads toward the marker.

The left and right S1 leads have the same numerical designation as the jack and the associated secondary switch. These leads are strapped at corresponding contacts of the TL and TR relays for connection to the secondary switch horizontals. The SA, SB, EA or EB lead for the ten secondary select magnets also has the same numerical designation and is strapped at the SS relays.

In addition, the full selector outgoing trunks can be made busy at the outgoing trunk test board, while call indicator trunks may be made busy by the operation of a key at the distant manual office.

OFFICE FRAME MAKE BUSY

MB

To make an office frame busy a plug with the tip, ring and sleeve strapped is inserted in the OMB jack causing the associated MB relay to operate. Operation of the MB relay of an office link frame opens the MB lead to its mate frame, preventing both office frames in the pair from being made busy at the same time. The MB relay, when operated, lights the frame FB lamp, connects ground to the FB lead to the floor alarm frame for visual signal that the frame busy and connects ground to the MB lead at the MCA relays of its mate frame.

The connection of ground to the MB lead to the other frame of the pair causes the decoder marker circuit BE or BO relay to operate and cause to appear busy the trunks on the frame that is taken out of service. This path is closed when the MCA relay on the mate frame operates on a call. This prevents the selection of a trunk on the frame that is made busy.

The operating paths of the MCA relays on the frame that is made busy are opened at the contacts of the operated MB relay.

OFFICE LINK FRAMES TRANSFER

CH

Each office link and connector frame has an MP relay for each marker, these relays being wired in a chain circuit for preference and to prevent double connections. As previously described, the MP relays on the even numbered frame of each pair of frames are ordinarily used to control the marker connections to both frames. The MP relays on the odd frame, however, are automatically substituted for those on the even frame in case of trouble and can be substituted for them manually by the operation of keys, if desired, for maintenance purposes.

Each even numbered frame has a circuit per figure 7, which includes relays CH, TR1, TR2, TR3, TR4 and MB, an OMB jack, an MTR key and an SA key. Each odd numbered frame has a circuit per figure 16, which includes the CH, TR1, TR3, TR4 and MB relays, an OMB jack and an MTR key. All of this equipment on both frames is controlled as one circuit. It is separated so that, in case of a fire, certain relays can be blocked to provide service.

Two CH relays are required on these frames because there are four chain circuits which are checked on these MP relays. The CH relays are differential and operate only when one inductive winding is energized and not the other. They are slow operate to prevent them from operating falsely if the circuit through one winding should be opened slightly before the other in regular operation.

The transfer functions the same as described for the trunk link frames.

SENDER AND MARKER TEST CALLS

SPECIAL CONDITIONS

SENDER TEST CALLS

On calls from the sender test circuit, the marker functions must be cancelled since on such test calls the ability of the marker to close a channel is not a function of the sender. The code setup in the sender, however, by the test circuit must be translated by the marker.

On sender test circuit calls after having received the office code, the sender connects to a marker circuit as in a regular call. The code information is transferred to the marker as in a call from a subscriber. In addition, the sender test circuit connects ground to the SDT lead closed through the marker connector to the marker operating the SDT1 relay. The SDT1 relay closes ground to the ST lead operating the marker SDT multi-contact relay, which operates the SDT2 relay. The sender test circuit connects ground to the TIB lead through the connector to operate the marker SDTA relay.

The SDT multi-contact relay connects the receiving leads to the test circuit in order that the test circuit can make a check of the code, frame and other information, received by the marker from the sender under test.

The office frame start lead, group start, group end and trunk level leads are opened by the operation of the SDT2 relay preventing this information from being registered.

The TIB relay is also operated at this time provided there is not a call in the marker stage. If there is a call in the marker stage, operation of the TIB relay is delayed until the ST3 relay releases.

When the TK relay operates, after the decoded information has been transmitted to the sender, it connects ground to the "RLG" lead to the SDR TST circuit. This causes the sender test CCT to connect GRD to RL lead to marker and back to sender, causing release of connector and marker.

In order to test the sender for proper procedure on receiving a first, second or third trouble release signal on certain test calls, ground is held on the BO and B1 leads. This causes the marker to block and the XR1 and XX1 relays to operate. The DL relay now operates, in turn, operating the TR relay which causes ground to be connected to the TRL lead to the sender. This causes the sender to remove battery from the DST lead, releasing the marker.

The sender again connects battery to the DST lead selecting another marker. If ground is still held on the BO and B1 leads in the sender test circuit, the second marker will also time-out and a second trouble release will be given to the sender, releasing the marker.

The sender again connects to a marker for a third trial and if the BO and B1 leads are grounded the marker blocks and a third trouble release is given to the sender.

MARKER TEST CALLS

Facilities are provided in the trouble indicator circuit for making routine tests on the marker circuits. A marker can be seized for a test call by operation of the DT key and the ST key in the trouble indicator circuit. Operation of these keys causes certain relays in the trouble indicator circuit to operate and connect ground to the CIF1 and DB leads to the marker. The operation of the DMT relay opens the trunk group peg count and overflow traffic register leads preventing these registers from being scored on during marker test calls.

Ground on the CIF1 lead causes the CIF1 relay to operate followed by the CIF2 and CIE relays. With the CIF1, CIF2 and CIE relays operate, the receiving, transmitting and check leads are connected between the marker and the trouble indicator circuit. Certain other leads are connected also so that the trouble indicator can duplicate the functions of the sender and the incoming trunk which are not connected on this type of call even though the trunk link and office frames are used.

In this call the marker translates the code, operates a route relay, causes the office link and trunk link frames to be connected and selects a trunk and channel as in regular operation, the trouble indicator circuit, however, providing the code and otherwise replacing the functions of the sender and also of the incoming trunk.

When the trunk link and connector circuit MP relay operates, it operates the associated MCA relay and also grounds lead DK1, operating the marker DK relay. The operation of the MCA relay grounds lead DK to the marker. This ground is extended through front contacts of relay DK and through the CIF relay contacts and operates the F relay in the trouble indicator circuit which duplicates the incoming trunk F relay in that it extends this ground back over the AK lead operating the AK relay.

The trunk link and connector circuit LC relay does not operate. The trouble indicator provides a resistance battery to replace battery through the trunk link primary hold magnet for operating the marker A relay. This battery is furnished on the ILS lead through operated contacts of the CIF1 relay. A relay in the trouble indicator circuit replaces the function of the trunk link primary hold magnet in extending the ground required for shunting the A relay and for operating the SL relay.

When the SLK relay operates, it connects ground to the TRB lead to the trouble indicator circuit. The trouble indicator circuit, in turn, connects ground to the TR lead operating the marker circuit TR relay. The TR relay provides a locking path for the DMT relay and connects battery to the TIS lead to the trouble indicator causing it to function for a record, the CIA, CIB, CIC and CID relays being used for this purpose as already described.

The trouble indicator circuit then connects ground to the TIB lead, operating the marker circuit TIB relay. This relay connects ground to the TRL lead to the trouble indicator and operates the RL relay in the marker. The RL relay is slow operate to insure that the trouble release signal is recorded before the marker restores to normal. The RL relay operates the MRL relay, which restores the marker as previously described. Ground is then removed from the TRL lead, releasing the trouble indicator circuit which, in turn, releases the CIA to CIE relays and the CIF1 relay. The CIF1 relay released, releases the CIF2 relay.

Should some actual trouble cause the marker to block, the trouble indicator will be connected by operating the CIA to CID relays as on a regular call.

TBL. INDICATOR

TBL. INDICATOR

Trouble Indicator Circuit SD-25363

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TROUBLE INDICATOR CIRCUIT

SD-25363

CONNECTION TO TROUBLE INDICATOR

OS -

DL

A trouble indicator circuit is provided for a group of decoder markers and is arranged for connection to any marker of the group that fails to complete its functions and release in a predetermined time. The time periods are measured by the marker circuits as previously described. The trouble indicator circuit takes a record of the call and restores the marker and its associated circuits.

TR

When a marker circuit operates its DL relay due to timing out or without counting time as described for the XX1 and XX2 relays in connection with the cross detecting relays, the marker TR relay operates.

The TR relay operated connects ground to the MR lead to the trouble indicator frame to score a register, connects ground to the DB lead to hold the marker busy and connects resistance battery to the TIS lead to operate the associated DS relay at the tandem trouble indicator. It also, connects ground to the DL lead to the trouble indicator to operate the DL relay.

DS

There is a DS relay in the trouble indicator circuit for each marker circuit which it serves. These relays are wired in a double transfer chain in order to provide preference and prevent double connections. Two or more DS relays can operate simultaneously but only one can cause its associated marker to be connected to the trouble indicator circuit.

DL

Two or more DL relays can operate and lock in case of simultaneous calls from markers or in case of calls while the trouble indicator is busy. Under these conditions they provide lamp signals as described later to indicate the marker circuits which were unsuccessful in connecting to the trouble indicator.

The DL relay connects ground to the TIL lead to the miscellaneous circuit for the trouble indicator frame for sounding the trouble indicator alarm.

CIA

The trouble indicator DS relay receiving the preference, operates the CIA relay of the associated marker. In case two or more DS relays are operated the preference starts at the last one. The marker nearest to this relay consequently operates its CIA relay.

CO

The trouble indicator grounds the CO lead to the marker, operating the CO relay to disconnect the transmitting leads from the winding of the XT relay to individualize the transmitting leads which are connected to the trouble indicator by the CIE relay.

TI

The CIA relay connects ground to the TI lead to the tandem link frame operating the TI relay. The trunk link and connector circuit TI relay is operated to prepare paths for taking a record of the trunk link primary switch and the primary switch select magnets operated for the call.

CIA,CIB,
CIC,CID,
CIE,CIF2

The multicontact relays operated connect all the required leads to the trouble indicator circuit to record the progress of the call. Of the leads that are connected to the trouble indicator, those that are grounded operate corresponding relays for this purpose as described in detail in the following paragraphs.

OPERATION OF TROUBLE INDICATOR RECORDING RELAYS

CF07,CN02,
SN04

The CIA relay operated connects ground to the FRG, SNG and CNG leads to the marker connector circuit. These leads are closed through operated multicontact relays in the connector to the FR, SN and CN leads respectively to the trouble indicator. The trouble indicator circuit includes one CF relay for each connector frame installed, designated 0 to 7 or as required, 5 SN relays, designated 0 to 4 and 3 CN relays, designated 0 to 2. The FR, SN and CN leads, which are connected to the windings of the CF, SN and CN relays are so arranged that one of each of these relays operates, indicating respectively the connector frame involved, the location of the sender in the connector and the location of the connector on its frame.

TF019,OF09
TL014

The trouble indicator circuit also includes a maximum of twenty TF relays, designated 0 to 5 or as required, a maximum of ten OF relays, designated 0 to 31 or as required and 15 TL relays, designated 0 to 14. The number of TF and OF relays installed is the same as the number of trunk link frames and the number of pairs of office link frames respectively and is consequently the same as the number of TF and O relays equipped in the markers. When the CIA relay operated, it closes the IF, OK and TL leads to the trouble indicator causing the TF, OF and TL relays corresponding to grounded leads to operate.

RL, MRL, RO, TB2, CRL, DT3, AK

The CIF2 relay operated closes leads RL, MRL, RO, TB2, CRL, DT3 and AK from the marker to the trouble indicator circuit. These leads terminate at the windings of correspondingly designated relays in the trouble indicator which operate if the leads are grounded.

KEL09, KOL09, KER09, KOR09, CHL09, CHR09

The CIB relay closes 20 CH leads and 40 K leads from the windings of the twenty CH relays and from the windings of the 40 K relays to the windings of correspondingly designated relays in the trouble indicator. The trouble indicator relays corresponding to grounded leads operate.

JC09, GT1, GT3, TB1, GS, P013, GOA, G1D

The CIC relay closes the GT1, GT3, TB1, GS, GOA to G1D, JCO to 9 and PO to 13 leads to the trouble indicator causing correspondingly designated relays to operate if the leads are grounded.

CKG, CK1, TR1, TR2, OF, TGF

The CIE relay operated connects the receiving and transmitting leads to the windings of correspondingly designated relays in the trouble indicator, the leads that are grounded causing the corresponding relays to operate. It also closes the CK1, OF, TR1, TR2 and TGF leads operating corresponding relays.

The CID relay closes X leads and miscellaneous leads causing corresponding relays to operate if the leads are grounded.

M09

The trunk link and connector circuit TI relay operated closes 10 M leads to the trouble indicator and causes one of 10 LC leads to be grounded, corresponding to the LC relay operated. A grounded M lead causes the corresponding M relay to operate and indicate the trunk link primary switch select magnets operated and a grounded LC lead operates the corresponding SW relay indicating the trunk link primary switch involved.

DISCONNECTION FROM THE MARKER

DR

The trouble indicator circuit is arranged to lock in the record and to disconnect from the marker causing it to release its associated circuits and to restore. This takes place due to operation of the CID relay which operates the DR relay in the trouble indicator corresponding to the marker involved.

This causes the RT, RT1 and HD relays to operate followed by the release of the RT and RT1 relays and the operation of the RD and RM relays. The release of the RT1 relay removes ground from the CIA lead releasing the CIA to CIE, CIF2 and CO relays of the marker.

The slow operate RT1 relay and the slow release RT relay serve to time the period during which the recording relays operate before the marker is released.

TIB

The operation of the RM relay operates the TIB relay in all markers. The TIB relays operated in other markers cause them to send trouble release signals and to restore without waiting for the trouble indicator, if these circuits should also time-out.

DISPLAY OF RECORDS

Each recording relay operated in the trouble indicator prepares a path for lighting a lamp which is designated so as to identify the particular function associated with its recording lead in the marker; except that, in a few cases, operation of the recording relay opens the lighting circuit of the lamp, as it is necessary to use the absence of ground on the recording lead to indicate the operation of a relay in the marker.

In response to the trouble indicator alarm the recorded information is displayed by operation of the trouble indicator circuit LP key, which locks and operates the LP relay. The LP relay connects ground to all of the recording relays, causing these lamps which have closures as a result of the operation or non-operation in some cases, of the recording relay to light.

The markers are arranged to decode a second call while completing the marker functions for a preceding call. Therefore, there may be one or two calls in the marker at the time the trouble indicator is summoned. When there are two calls, the one in the decoding stage can only summon the trouble indicator if the XX1 relay has been operated by the XOB, XOG, XCR or XCL relay, otherwise, the selection of the trouble indicator is delayed until after the preceding call in the marker stage has been completed. Thus, when the trouble indicator is summoned while two calls are being handled, only under the above stated condition can the second call be responsible for its selection.

In this case, since the recording relays operated for the first call have been released and those required for the second call have been operated, the record taken will show the code, class of call and trunk link frame information, the sender, marker connector and connector frame numbers and the condition of the transmitting leads as applying to the second call rather than the first. If only one call is being handled and it encounters a trouble in the marker stage, this information will not be shown at all since the recording relays have been released and not reoperated.

Whether one or two calls are being handled by the marker can be determined from the CK1 and MS lamps as described in detail below. The trouble indicator circuit CK1 relay operates and prepares a path for lighting its associated lamp if there is ground on the CK1 lead of the marker indicating that a sender is connected. The MS relay operates and prepares a path for lighting its associated lamp if there is ground on the MS lead of the marker (ST3 relay operated) indicating that a call is being handled in the marker stage.

LAMP INDICATIONS

The lighted lamps in the trouble indicator circuit indicate the circuit conditions in the marker as follows:

CK1 lamp lighted and MS lamp out indicates that a marker connector is connected, that only one call is being handled by the marker and that the trouble encountered by the marker is in the decoding stage.

CK1 lamp out and MS lamp lighted indicates that a marker connector is not connected, that only one call is being handled by the marker and that the trouble encountered is in the marker stage.

CK1 and MS lamps both lighted indicates that a marker connector is connected, that two calls are being handled by the marker and that the trouble encountered is in the first call in the marker stage.

The lighted DL lamp indicates the marker circuit from which the record was taken. There is one of these lamps for each marker.

Lighted DL lamps indicate markers that failed and were released without a record being taken, while the trouble indicator was busy. There is one of these lamps for each marker.

The CF, CN and SN lamps indicate the connector frame, connector circuit and sender involved if a sender is connected. One of each of these lamps lights.

The BO4, BB5, BA5, GO4, GB5, GA5, FO4, FB5, FA5, FOO and F10 lamps indicate corresponding grounded receiving leads, except that falsely grounded or open leads are indicated respectively.

For example, a falsely grounded receiving lead not required for the call may cause the operation of the XR relay or an open receiving lead may cause a time-out in the first stage of timing.

The TR1, TR2 and OF lamps indicate first, second and third trials respectively, while both the TR1 and OF, or TR2 and OF may be operated, when the marker calls for an overflow trunk in a first or second trial call.

The TGF lamp indicates that the sender associated with the call had failed on terminating incoming trunk test.

Transmitting lead lamps indicate the information transmitted to the sender by the marker for the particular code, each lighted lamp indicating that the corresponding transmitting lead is grounded.

The TF, OF, P, JC and TL lamps indicate respectively the trunk link and connector frame number as translated by the marker, the number of the office link and connector frame relay operated in the marker, the number of the P relay operated, the number of the JC relay operated and the number of the TL relay operated.

Each OF lamp represents a pair of odd and even numbered office frames and if an even numbered trunk lamp (KEL-0 to KOR-9, described below) is lighted, the even frame of the pair is the one on which the trunk is located. If an odd numbered trunk lamp is lighted, the trunk is located on the odd frame of the pair.

The M and SW lamps indicate respectively the trunk link primary select magnets operated, two for each call and the trunk link primary switch at which the incoming trunk involved in the call terminates.

These indications are taken directly from the trunk link and connector circuit which is connected to the marker at the time the record is taken.

The M and SW lamps together with the TF lamp correlate the incoming trunk number and its associated trunk frame. The number of the TF lamp and the number of the M lamp in the group 2 to 9 when lighted, indicate respectively the tens and units digit of the trunk frame number on which the incoming trunk appears. The number of the TF lamp, the number of the M lamp in the group 2 to 9, the 0 or 1 M lamp and the SW lamp 0 to 9, when lighted, indicate respectively the thousands, hundreds, tens and units digit of the incoming trunk involved on the call.

The CH lamp (L-0 to R-9 lighted indicates the CH relay operated in the marker and consequently the channel selected. The numerical part of the designation of the lamp is the same as the number of the trunk link secondary switch and the office link primary switch involved and the left and right half switches correspond to the "L" and "R" lamp designations.

The K lamp (EL-0 to OR-9) lighted corresponds with the K relay operated in the marker. From this indication the office frame (even or odd) of the pair, the left or right half switch on which the trunk is located (if the trunk level is split) and the office link secondary switch and consequently the primary switch level can be determined. There are forty of these lamps, one for each similarly designated K relay in the marker circuit.

The GS lamp indicates the GS relay operates in the marker and that the call had progressed to a second route relay.

The GT1 and GT3 lamps indicate respectively that the marker was blocked while associated with the first or second subgroup of a split trunk group.

The 0A to 0D or 1A to 1D lamps indicate respectively which one of two subgroups, if involved on a call, were connected when the marker blocked.

The XCR, XCL, XOF, XTL, XSS, XGS, XGE and XR lamps indicate that due to a false ground or a cross, two or more windings of relays in the corresponding group are energized or two or more relays in the group are operated.

The XT lamp indicates that one or more transmitting leads to the sender are falsely grounded.

The XSL lamp indicates a false ground on the SL lead to the trunk link and connector circuit.

The XSM lamp indicates a falsely grounded or crossed SML or SMR lead to the office link and connector circuit.

The XK lamp indicates a false ground on the even or odd SP or NS leads or the PSA or PSB leads or the SSA or SSB leads or on the CK lead to the office link circuit or on the SSA or SSB leads.

The XTL1 lamp indicates a falsely grounded TL lead to the office link and connector circuit.

The XCH lamp indicates a false ground on the S or LS leads to the trunk link and connector circuit or on the LS leads to the office link and connector circuit.

The XLCE or XLCO lamp indicates a falsely grounded LC lead to the even or odd office link frame respectively.

The XS lamp indicates a false ground on the S lead of the selected outgoing trunk.

The XS1 lamp indicates a falsely grounded S1 lead to the office link and connector circuit.

The XX1 lamp indicates that the XX1 relay in the marker has operated.

The XRL lamp indicates that the marker XRL relay has operated due to a false ground on the RL, RO or TRL lead.

The SDT lamp indicates a falsely grounded ST or SDT lead of the sender test circuit connector.

The XDC lamp indicates a false ground on the DC lead to the connector.

The XIF1 lamp indicates a false ground on the ST lead to the trunk link and connector circuit or a false ground on the SB lead to the office link and connector circuit.

The XSM1 lamp indicates that two or more trunk link primary select magnets in the group 2 to 9 have operated.

The XR1 lamp when lighted with the XR lamp extinguished, indicates that two of relays TR1, TR2 and OF were operated in the marker.

The CK1 lamp indicates that both the CK1 and CK2 relays were operated at the time of the failure.

The TB1 or TB2 lamp indicates that all trunks were found busy in the first of three subgroups or in a single or last subgroup respectively.

The SPE, SPO, NSE and NSO lamps indicate respectively the operation of the corresponding relays in the marker.

The DK and AK lamps indicate respectively that the DK and AK leads to the trunk link and connector circuit were grounded.

The AC lamp indicates whether the AC relay is operated or released. It is lighted through the operated contacts of the AC relay.

The BK lamp indicates that the trunk link and connector circuit has grounded the BK lead and that the CK and BK relays in the marker were operated.

The CK lamp indicates that the office link and connector circuit has grounded the CK lead and that the CK relay in the marker was operated.

The CHE lamp indicates the operation of the CHE relay in the marker or that the channel has not been seized.

The TKE lamp indicates operation of the TKE relay in the marker or that the outgoing trunk was not seized. This relay operates before a trunk is selected with all the K relay normal, and releases when a K relay operates. Consequently this lamp lights only if the marker circuit blocks with its TKE relay operated.

The TK lamp indicates correct operation of the lettered transmitting relays for checking the transmitting leads required for the call and that the TK relay in the marker is operated.

The SR lamp indicates that the SR relay in the marker is operated and has released the connector.

The A and C lamps are controlled by operated contacts of the A and C relays in the marker and if lighted indicate respectively operation of the trunk primary and office secondary hold magnets and failure of the corresponding relay to be short-circuited and released by operation of the trunk link secondary hold magnet or the office primary hold magnet.

The S lamp indicates that the S lead of the selected trunk has been grounded by operation of the office secondary hold magnet and that the S relay in the marker should have operated.

The SL lamp indicates that the SL lead from the trunk link and connector circuit has been grounded by operation of the trunk link primary hold magnet and that the SL relay in the marker should have operated.

The B lamp indicates operation of the B relay in the marker. Unless trouble is encountered this relay is shunted down by the release of the F relay in the incoming trunk circuit.

The SIK lamp indicates operation of the SIK relay in the marker and therefore that the S1 lead of the selected trunk was grounded by operation of the office secondary hold magnet.

The MRL lamp indicates operation of the MRL relay in the marker and that trouble was encountered by the marker circuit which prevented it from returning to normal.

The TM6 lamp indicates that the TM6 relay is operated. This lamp is for the purpose of indicating that the trouble indicator was selected on account of a time-out and not by the operation of an X - relay.

The CRL lamp indicates that the marker failed to return to normal after finding all channels busy.

The DT3 lamp indicates that the marker failed to return to normal after encountering a false ground or a make busy ground on the S1 lead of the selected trunk during the double connection test.

The RO lamp indicates that the marker failed to return to normal after transmitting a reorder signal to the tandem sender.

The RL lamp indicates that the RL lead of the marker is grounded, thereby transmitting a sender release signal.

RELEASE OF TROUBLE INDICATOR CIRCUIT

RL KEY

To extinguish the lighted lamps and return the trouble indicator circuit to normal, the RL key is operated momentarily. This operates the KR relay which releases any operated DL relays and extinguishes the DL lamps. The lighted trouble indicator lamps are extinguished. The TIB relays release in all markers when the trouble indicator circuit becomes normal, making it available for service.

TROUBLE INDICATOR MAKE BUSY

A make busy jack, designated TIB, is provided in the trouble indicator for each associated marker so that the trouble indicator may be made busy to any or all marker circuits as desired. These jacks are mounted on the trouble indicator frame. Insertion of a plug with the ring and sleeve strapped in one of these jacks connects ground to the TIB lead of the associated marker, thereby making the trouble indicator busy to that particular circuit.

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